RESPONSE OF COOKED FREEZE-DRIED COMBINATION MEAT ITEMS TO OXYGEN

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May 1970

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Food Laboratory
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Foreword

The adverse effects of oxygen on freeze-dried foods has been recognized from the beginnings of the Armed Forces program to develop freeze-dried rations. Current specifications for freeze-dried meat items include a maximum limit of 2 percent oxygen in the headspace gas. Storage studies as well as use in the field have shown that this limitation is valid and the products are satisfactory for the intended use. However, foods are very complex and their response to oxygen varies widely from item to item. Since packaging with low oxygen content is expensive and an inspection probelm as well, studies on individual items are necessary to establish their oxygen "tolerances".

The main component items in the Food Packet, Long Range Patrol are dried as complete items rather than as separate ingredients. Thus, they represent a new family of freeze-dried combination foods. Therefore, this study was started to determine the oxygen response of various types of products made this way.

The work was performed under project 1J6-62708-D553, Food Processing and Preservation Techniques.

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

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Abstract

Eight freeze-dried combination meat items used as main components in the Food Packet, Long Range Patrol were packed with different amounts of oxygen in the headspace gas and stored at 100°, 70°, 40°F. with withdrawals at 0, 2, 4, 12 and 24 weeks. The eight items were beef hash, beef stew, beef with rice, chicken and rice, chicken stew, chili con carne, pork with potatoes, and spaghetti with meat sauce. Oxygen uptake was determined. With the product stored at 100°F., the product was also evaluated by a 10-member technological panel and the rehydration ratio determined.

Regression analysis showed that flavor and odor correlated highly with oxygen uptake and the slopes of the regression lines were almost identical for the eight items. No correlation was found between rehydration ratio and oxygen uptake. Analysis of variance indicated that vacuum, temperature and time had significant effects on oxygen uptake, but the relative importance of temperature and time was different for different products. Multiple linear regression equations were derived using oxygen available, temperature, and time as independent variables and oxygen uptake as the dependent variable. The multiple correlation coefficients ranged between 0.61 and 0.79. Highly significant linear correlation coefficients were found with the regression of time on log mol fraction of oxygen remaining. This indicates that the oxygen uptake reactions have attributes of a first order reaction.

Introduction

Adverse effects of oxygen on freeze-dried foods have been noted by many investigators. A large number of in-house storage studies have shown that most freeze-dried foods are stable enough for military storage and use if they are packed with less than 2 percent oxygen in the headspace gas or if they are vacuum packed at 28-inches vacuum or better. Furthermore, regular procurements amounting to many thousands of pounds in the last ten years for both field and garrison use have confirmed the validity of these oxygen requirements.

Sharp (1953) and Harper and Tappel (1957) pointed out that freeze-dried meat takes up oxygen and that deterioration results. Olcott (1962) stated that there is a rapid loss of palatability when freeze-dried meat and fish are stored in oxygen or air. Smithies (1962) stated 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. Exposure to oxygen appears to be the most significant factor in the degradation of freeze-dried beef, chicken, carrots and spinach (Koth <u>et al.</u>, 1965).

Storage temperature is generally considered to have a very significant effect on the storage life of freeze-dried foods. Hanson (1961) reported generalized results from a large number of studies and stated that a dehydrated food which will keep for 2 years at 60° - 70°F. could be expected to last 12 - 18 months at 80°F., 6 - 8 months at 90°F., 3 months at 100°F., and about 2 weeks at 120°F. These products were packed with less than 2 percent oxygen in the headspace. Freeze-dried meat items intended for operational rations are routinely stored for 12 months at 100°F. during the development cycle and must receive satisfactory ratings from a consumer taste panel at the end of that period. In general, results from these studies agree with Hanson's findings except that freeze-dehydrated combination meat items appear to be more stable in storage than Hanson reports.

The Food Packet, Long Range Patrol has been very well received in the field and the quality has been considered excellent. However, theproducers have been quality conscious and have gone out of their way to meet and exceed specification requirements. Too little is known about the quality parameters of the packet components, however, in particular the effect of oxygen during storage at various temperatures. Therefore, this study was initiated to determine the effect of oxygen on the 8 main component items in the Food Packet, Long Range Patrol and how the oxygen uptake is affected by storage time and temperature. The products studied were beef hash, beef stew, beef with rice, chicken and rice, chicken stew, chili con carne, pork with potatoes, and spaghetti with meat sauce.

Experimental Methods

The products were made in accordance with Interim Purchase Description IP/DES S-36-6, Food Packet, Long Range Patrol, dated April 20, 1966. Due to the large number of samples involved, the study was divided into two parts. In the first part, the products were stored at 100°F. and evaluated by a technological taste panel as well as by analysis of the headspace gas. In the second part, the products were stored at 70°F. and 40°F. with formal technological panel evaluation being omitted. Each product was made as a single batch for each part of the study and dehydrated in one freeze-dehydration chamber. Dehydration was to less than 2 percent moisture and the vacuum in the chamber was broken with nitrogen. Freeze-dehydration conditions were 120°F. platen temperature with radiant heating and a pressure of 400 microns. Packaging was in No. 2-1/2 cans and was accomplished within four hours after the dehydrator was opened. Twenty five cans for the first part of the study and fifty cans for the second part 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 30 seconds 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 actually attained corresponded to approximately 1, 2, 3.5, 5, 6, 7 and 21 percent oxygen if the cans had been gas packed. A total of 525 cans were stored with 175 cans being stored at each of the three temperatures. Five cans of each vacuum at the three temperatures were withdrawn for evaluation at 0, 2, 4, 12 and 24 weeks. Moisture content of the stored product was 1 - 2 percent.

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 ambient pressure with nitrogen and allowed to equilibrate overnight at ambient temperature. Sample size was 250-500μℓ. Experience indicates an anticipated error for the method of approximately ± 0.25 percent. Results for the 5 cans at each level were averaged for reporting purposes.

Total headspace volume in the filled cans was determined by compressing 125 grams of product in a laboratory press at 5000 lbs. per square inch for 10 seconds and subtracting the volume of the resulting bar from the total volume of the can. This method is not completely accurate. However, since the volume of headspace gas was so large in comparison with the absolute volume of the product any resulting error was considered insignificant.

Taste panel evaluation was 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. The same panel was used for all evaluations. Product was rehydrated with water at 180°F. for 5 minutes for tasting. Product in the cans used for chromatographic analysis was used for the panel evaluation.

Rehydration value was obtained by rehydrating 125 grams of product with water at 180°F. for 5 minutes, draining the product for 1 minute on a wire screen with 1/8-inch square openings and reweighing. Rehydration ratio was calculated as weight of rehydrated product divided by weight of dry product.

Results and Discussion

Tables 1 through 8 show the average panel flavor, odor, and texture ratings for the eight items in the first part of the study. Table 9 gives the analysis of variance for these results and indicates that oxygen available and storage time at elevated temperature are two important factors in the deterioration of freeze-dried foods. The Duncan Multiple Range test shows that with five of the eight items there is no significant difference at the 1 percent level between the flavor rating means at full vacuum through 26 inches. Chicken and rice, beef with rice, and chili con carne show no significant difference between full vacuum and 20 inches, which suggests that these three items are less sensative to oxygen than the other five. For all eight products where vacuum is shown to be significant in Table 9 for odor and texture, the Duncan Multiple Range test shows that there is no significant difference between full vacuum and 20 to 22 inches. Thus, in an overall evaluation of the effects of available oxygen in the products, the effect on flavor would be the controlling factor. Rehydration ratios were not significantly different over the full vacuum and storage time ranges and, therefore, no data are presented.

Table 10 shows the linear correlation coefficients for oxygen uptake (Tables 12 through 19) versus the technological panel results (Tables 1 through 8) over the entire range of the study. Odor and flavor correlated highly with oxygen uptake whereas texture generally did not correlate quite as high and for three products did not correlate at all at the 5 percent level of significance. It should be noted as stated above there is no significant difference in the upper part of the vacuum range. Slopes of the regression lines for flavor (Table 11) are almost identifical indicating that a given oxygen uptake will result in an equivalent decrease in organoleptic ratings for each product. However, the rate of oxygen uptake is not the same for all items under the same conditions.

Oxygen uptakes at the three temperatures are shown for the eight items in Tables 12 through 19. Analysis of variance for these uptakes and percentage of variation assignable to each factor as determined by the method of Hicks (1956) are given in Table 20. The main factors of vacuum, temperature, and time were significant at the 1 percent level for all eight items. Most of the two factor interactions were significant at either the 1 percent or the 5 percent level. All of the interactions were in the same direction as the main factors as determined by inspection of the data.

Inspection of the components of variance indicates that the eight products can be divided into two general classes according to the factors which contribute the largest percentages to the variance. This is shown in Table 20A. In the first class which includes beef with rice, chicken and rice, pork with potatoes, and chicken stew, the major portion of the variance was caused by vacuum, temperature, and the vacuum X temperature interaction. In the second class which includes the other four products, the major portion of the variance was caused by vacuum, time and the vacuum X time interaction. The reasons for the products dividing into these two general classes are not well understood. However, the implications are very important in the design of military operational rations. Temperature can be controlled for the long term storage of contingency and reserve stocks. In operational situations, temperature depends upon the geographic location and very little controlled temperature storage can be provided. Time then becomes the important factor. It is evident that much more information is needed in this area.

The percentage of available oxygen taken up by the eight items packed in air and stored at the three temperatures is shown in Table 21 illustrating the wide difference in responses of the items. Beef with rice and chili con carne appear to be less susceptible to oxygen at 100°F. than do the other six items. However, at 70° and 40°F, the responses of chicken and rice and chicken stew are very similar to them. The oxygen uptake of spaghetti with meat sauce was the same for all three temperatures. Although the effect of temperature over the whole study was significant (Table 20) it contributed only a very small amount to the total variance.

Multiple linear regression equations were calculated from the data in Tables 12 through 19 using oxygen uptake as the independent variable (y) and oxygen available, temperature, and time as the dependent variables (X_1, X_2 and X_3). The derived equations are shown in Table 22 along with the mulitple regression coefficients (R_1, R_2 and R_3). The coefficients indicate good linear relationships and analysis of variance indicates that the contribution of each of the independent variables in each case was significant at the 1 percent level. Inspection of the raw data would suggest that the dependence of oxygen uptake on temperature and on time is probably curvilinear. However, the multiple correlation coefficients were not significantly improved when various mathmatical functions of time and temperature were used to develop the equations.

Nomographs can be developed from the regression equations which can be used to predict storage life of the product under different storage conditions by relating oxygen uptake to taste panel ratings. However, the data were obtained over a six month period and extension beyond that time cannot be justified. Furthermore, variations in raw materials, processing, and handling plus inherent variations in the subjective ratings obtained by taste panels rule out using the equations for anything more than generalized conclusions regarding storage stability of the eight products.

Correlation coefficients (r) were calculated for the linear regression of time on the log of mol fraction oxygen remaining (Table 23). In all cases except for chicken stew at 40°F., the coefficients are significant at the 1 percent level at each temperature. With chicken stew at 40°F. the oxygen uptake was so low that the points tend to cluster since the experimental error was of the same magnitude as the effect. The coefficients indicate a good linear relationship, a relationship usually considered a criterion for a first order reaction. This would indicate that the reactions involved are different from those usually associated with the normal oxidative rancidity of meat.

The results of this study confirm the adverse effects of oxygen uptake by freeze-dried combination items, and reinforce Armed Forces specification requirements restricting headspace oxygen to a maximum of 2 percent for operational rations where lengthy storage under possible adverse conditions must be anticipated. However, results also show that certain products are more resistant to oxygen uptake than others. Investigation of these differences should lead to improved product formulations which would permit a larger margin of error in handling and packing.

Table I. Panel Ratings for

BEEF HASH - Stored at 100°F.

TIME (WKS)	30"			28"			26"			24"			22"			20"			0"		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Text.	Flavor	Odor	Texture
0	6.2	6.5	5.8	6.2	6.5	5.8	6.2	6.5	5.8	6.2	6.5	5.8	6.2	6.5	5.8	6.2	6.5	5.8	6.2	6.5	5.8
2	6.3	6.5	6.0	6.2	6.4	5.9	5.6	5.6	5.4	6.2	6.7	5.8	5.7	5.7	5.5	5.5	5.6	5.5	5.1	5.8	5.2
4	6.1	6.3	5.7	5.9	5.9	5.2	6.3	6.7	5.5	4.7	5.6	5.3	5.5	6.5	4.6	6.0	6.8	5.3	4.3	5.0	4.9
12	6.3	6.4	5.3	5.1	5.1	4.9	4.4	5.1	5.0	5.2	5.8	4.8	4.7	5.6	4.8	4.4	5.5	4.4	1.6	2.5	4.0
24	5.8	5.6	5.3	5.6	5.7	5.3	5.5	6.1	5.4	3.9	5.3	4.8	4.4	5.0	4.7	4.9	5.6	5.6	3.1	4.3	5.3

Table 2. Panel Ratings for

BEEF STEW - Stored at 100°F.

TIME (WKS)	30°			28°			25°			24°			22°			20°			0°		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture
0	6.5	6.4	6.1	6.5	6.4	6.1	6.5	6.4	6.1	6.5	6.4	6.1	6.5	6.4	6.1	6.5	6.4	6.1	6.5	6.4	6.1
2	6.9	6.9	6.0	6.4	7.0	6.0	7.1	7.3	6.4	6.6	6.3	5.3	6.4	6.4	5.7	5.7	5.9	5.1	4.5	5.9	5.1
4	6.7	6.8	5.	6.2	6.2	5.1	5.3	6.7	5.6	4.4	5.7	5.0	5.6	6.2	5.4	4.6	5.8	4.9	4.3	5.5	5.2
12	6.4	6.2	5.9	6.3	6.8	6.1	5.4	5.7	5.6	4.9	6.1	5.2	4.4	5.1	5.1	4.3	5.4	5.0	3.3	3.8	4.4
24	6.6	6.2	6.3	6.3	6.1	5.9	6.2	5.9	5.6	4.8	5.3	5.7	4.2	4.9	5.9	5.0	5.1	5.3	2.3	3.4	4.3

Table 3. Panel Ratings for

BEEF & RICE - Stored at 100°F.

TIME (WKS)	30"			28"			26"			24"			22"			20"			0"		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture
0	6.8	6.7	6.0	6.8	6.7	6.0	6.8	6.7	6.0	6.8	6.7	6.0	6.8	6.7	6.0	6.8	6.7	6.0	6.8	6.7	6.0
2	7.0	7.0	6.5	6.3	6.5	5.5	6.4	6.9	6.1	5.8	6.3	5.7	6.5	6.8	6.0	6.7	7.1	6.3	5.8	6.3	5.8
4	7.0	6.7	6.2	6.6	6.5	6.0	6.1	6.1	5.9	6.0	6.3	6.1	6.1	6.3	5.6	6.3	6.4	6.6	5.1	5.9	5.4
12	6.9	6.5	6.5	6.3	6.5	5.9	6.0	6.5	6.2	6.5	6.5	6.2	6.1	6.4	6.0	6.4	6.6	6.2	5.8	6.3	6.2
24	5.9	5.8	4.8	6.4	6.1	5.4	6.1	5.7	5.1	6.3	6.0	5.6	5.9	5.6	5.6	5.8	5.6	4.9	5.0	5.5	5.4

Table 4. Panel Ratings for

CHICKEN & RICE - Stored at 100°F.

TIME (WKS)	30°			28°			26°			24°			22°			20°			0°		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture
0	6.7	7.0	5.9	6.7	7.0	5.9	6.7	7.0	5.9	6.7	7.0	5.9	6.7	7.0	5.9	6.7	7.0	5.9	6.7	7.0	5.9
2	6.7	6.8	6.6	6.6	6.8	5.8	6.3	6.8	6.0	6.2	6.7	5.9	5.8	6.5	5.7	6.0	6.8	6.4	5.4	6.1	5.4
4	6.4	6.7	6.3	6.1	6.2	5.5	6.6	6.6	6.1	5.7	6.2	5.6	6.4	6.6	5.6	6.0	6.5	5.6	4.1	5.5	5.0
12	6.6	6.7	6.2	5.2	5.8	5.7	5.9	6.2	5.4	5.4	6.3	5.7	5.6	6.3	5.2	5.2	6.1	5.1	3.3	3.4	4.6
24	6.3	6.5	6.2	6.2	6.4	5.9	6.1	6.4	6.1	5.8	6.3	5.8	6.2	6.6	6.2	6.1	6.0	5.9	3.1	4.0	5.2

Table 5. Panel Ratings for

CHICKEN STEW - Stored at 100°F.

TIME (WKS)	30°			28°			25°			24°			22°			20°			0°		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture
0	6.7	7.2	5.1	6.7	7.2	5.1	6.7	7.2	5.1	6.7	7.2	5.1	6.7	7.2	5.1	6.7	7.2	5.1	6.7	7.2	5.1
2	6.4	6.8	5.7	6.7	6.8	5.1	5.9	6.7	5.2	5.7	6.7	5.0	5.8	5.2	5.8	6.0	6.8	5.4	4.9	6.2	5.1
4	6.7	6.8	5.2	6.5	6.8	5.4	6.4	6.7	5.6	4.7	6.0	5.1	6.3	5.8	6.3	6.1	6.7	5.5	4.9	5.8	4.8
12	6.5	6.5	5.8	5.7	6.2	5.9	4.7	5.9	5.6	4.6	6.0	5.5	5.5	6.2	5.8	5.4	6.1	5.6	4.7	6.0	5.6
24	6.0	6.5	5.3	5.5	6.1	5.3	5.1	5.9	5.3	4.5	5.5	4.8	4.6	5.7	5.1	4.1	4.7	4.4	2.5	3.8	4.3

Table 6. Panel Ratings for

CHILI CON CARNE - Stored at 100°F.

TIME (HRS)	30°			28°			26°			24°			22°			20°			0°		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture
0	7.0	6.7	6.3	7.0	6.7	6.3	7.0	6.7	6.3	7.0	6.7	6.3	7.0	6.7	6.3	7.0	6.7	6.3	7.0	6.7	6.3
2	6.6	7.1	6.6	6.3	6.9	5.9	6.0	6.6	5.8	6.2	6.8	6.2	6.1	6.8	6.0	5.6	6.7	5.6	5.2	6.1	5.7
4	6.2	6.0	5.5	6.0	6.2	5.6	6.5	6.1	6.0	6.0	5.7	5.6	5.3	5.7	5.4	5.8	6.2	5.6	3.9	5.2	5.6
12	6.6	7.0	7.0	6.3	7.1	5.7	6.1	6.4	6.0	5.3	6.4	5.6	4.9	5.6	5.6	4.9	5.8	5.4	3.1	3.9	3.7
24	6.5	6.8	6.3	6.1	6.6	6.3	6.2	6.7	6.2	6.1	5.9	6.4	6.0	5.9	6.1	5.4	5.8	6.1	5.5	5.7	6.0

Table 7. Panel Ratings for

PORK WITH POTATOES - Stored at 100°F.

TIME (WKS)	35°			28°			25°			24°			22°			20°			0°		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture
0	6.4	6.5	5.4	6.4	6.5	5.4	6.4	6.5	5.4	6.4	6.5	5.4	6.4	6.5	5.4	6.4	6.5	5.4	6.4	6.5	5.4
2	6.4	6.6	5.5	5.8	6.3	4.3	6.1	6.5	5.2	5.8	6.2	5.1	5.3	5.9	4.8	4.5	5.5	4.6	3.5	3.5	4.1
4	6.4	6.8	5.7	6.0	6.2	5.7	5.5	6.2	5.5	4.5	6.0	5.0	4.5	5.7	5.4	3.8	4.9	4.7	3.8	3.5	4.1
12	6.2	6.5	5.7	6.1	6.5	5.5	5.7	6.0	5.2	4.7	6.0	4.8	4.4	5.5	4.6	4.1	5.7	5.0	2.1	3.3	3.7
24	5.0	6.0	4.9	6.0	6.3	5.1	6.0	6.3	5.0	4.7	5.4	4.7	5.0	6.0	5.4	4.3	5.4	5.0	3.2	4.3	5.4

Table 8. Panel Ratings for

SPAGHETTI WITH MEAT - Stored at 100°F.

TIME (HRS)	30°			28°			25°			24°			22°			20°			0°		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture
0	6.3	6.4	5.7	6.3	6.4	5.7	6.3	6.4	5.7	6.3	6.4	5.7	6.3	6.4	5.7	6.3	6.4	5.7	6.3	6.4	4.7
2	6.3	6.3	5.6	5.3	6.0	5.8	6.0	6.2	5.8	4.6	5.5	5.2	5.0	5.4	5.1	5.1	5.1	5.6	3.1	4.0	4.5
4	5.8	6.4	5.7	5.9	6.3	5.5	5.2	5.5	5.2	5.1	6.0	5.5	4.6	3.7	4.7	4.7	4.7	4.8	2.9	3.9	4.6
12	6.5	6.8	5.8	5.9	6.6	5.5	6.2	6.2	5.7	5.2	5.9	5.4	4.8	5.3	5.1	4.3	4.3	4.8	1.5	1.8	2.1
24	6.3	6.2	6.0	6.0	6.3	5.6	5.4	5.5	5.5	3.4	4.5	5.0	3.2	4.1	4.8	2.5	2.5	3.5	1.0	1.0	1.0

Table 9. Analysis of Variance Results for Eight Combination Meat Items Stored at 100°F.

Product	Vacuum			Storage Time			Vacuum X Storage Time		
	Flavor	Odor	Texture	Flavor	Odor	Texture	Flavor	Odor	Texture
Beef Hash	xx	xx	n.s.	xx	xx	xx	xx	xx	n.s.
Beef Stew	xx	xx	x	xx	xx	x	xx	x	n.s.
Beef with Rice	xx	n.s.	n.s.	xx	xx	xx	n.s.	n.s.	n.s.
Chicken and Rice	xx	xx	xx	xx	xx	xx	xx	xx	n.s.
Chicken Stew	xx	xx	n.s.	xx	xx	xx	xx	xx	n.s.
Chili Con Carne	xx	xx	x	xx	xx	xx	xx	xx	n.s.
Pork with Potatoes	xx	xx	n.s.	xx	xx	n.s.	xx	xx	n.s.
Spaghetti with Meat Sauce	xx	xx	xx	xx	xx	xx	xx	xx	xx

xx Significant at the 1 percent level

x Significant at the 5 percent level

n.s. Not significant at the 5 percent level

Table 10. Correlation Coefficients (r) for Oxygen Uptake
vs. Technological Panel Results

Product	Flavor	Odor	Texture
Beef Hash	0.873^{xx}	0.823^{xx}	0.578^{xx}
Beef Stew	0.852^{xx}	0.879^{xx}	0.732^{xx}
Beef with Rice	0.766^{xx}	0.657^{xx}	$0.363^{n.s.}$
Chicken and Rice	0.876^{xx}	0.920^{xx}	0.648^{xx}
Chicken Stew	0.830^{xx}	0.823^{xx}	$0.193^{n.s.}$
Chili Con Carne	0.585^{xx}	0.667^{xx}	$0.344^{n.s.}$
Pork with Potatoes	0.887^{xx}	0.853^{xx}	0.499^{xx}
Spaghetti with Meat Sauce	0.859^{xx}	0.889^{xx}	0.937^{xx}

x Significant at the 5 percent level

xx Significant at the 1 percent level

n.s. Not significant at the 5 percent level

DF 27

Table 11. Linear Regression Equations for Ml. Oxygen Uptake (x) vs. Flavor Rating in a 9-point Scale (y)

Beef Hash	$y = 5.86 - 0.035x$
Beef Stew	$y = 6.46 - 0.032x$
Beef with Rice	$y = 6.56 - 0.035x$
Chicken and Rice	$y = 6.35 - 0.023x$
Chicken Stew	$y = 6.17 - 0.030x$
Chili Con Carne	$y = 6.18 - 0.024x$
Pork with Potatoes	$y = 5.81 - 0.024x$
Spaghetti with Meat Sauce	$y = 5.54 - 0.035x$

Table 12. Oxygen Uptake of BEEF HASH During Storage
(ml/125 gms of product)

TIME WKS	30"			28"			26"			24"			22"			20"			0"		
	O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML		
	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°
0	(5.0) 0	(2.0) 0	(2.0) 0	(10.6) 0	(8.9) 0	(8.9) 0	(19.7) 0	(18.5) 0	(18.5) 0	(30.4) 0	(28.3) 0	(28.3) 0	(38.7) 0	(37.7) 0	(37.7) 0	(49.2) 0	(46.6) 0	(46.6) 0	(158.9) 0	(158.9) 0	(158.9) 0
2	3.3	0	0	2.8	0	0.9	4.1	2.0	0.3	6.8	1.5	1.1	7.7	2.9	0.8	6.5	3.3	0	23.6	8.9	3.2
4	3.3	0.5	0.3	6.7	1.9	0.6	9.6	2.3	0.2	14.6	2.3	0.8	14.0	3.2	2.9	18.6	5.0	1.3	42.8	9.9	10.9
12	5.0	1.2	0.4	0.0	6.6	3.6	5.9	9.4	5.6	19.7	12.4	7.9	20.7	13.5	8.2	20.7	14.8	7.2	72.6	33.3	19.6
24	2.3	2.0	1.2	7.9	7.4	8.1	15.5	13.2	10.9	26.3	16.2	12.4	27.4	18.0	15.0	30.4	23.9	18.6	131.2	102.7	26.5

Headspace - 756.5　　( ) Avail. O_2　　Product - 125 gms.

Table 13. Oxygen Uptake of BEEF STEW During Storage
(ml/125 gms. of product)

TIME WKS	30"			28"			26"			24"			22"			20"			0"		
	O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML		
	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°
0	(5.9) 0	(1.5) 0	(1.5) 0	(14.9) 0	(9.4) 0	(9.4) 0	(26.7) 0	(19.2) 0	(19.2) 0	(35.6) 0	(28.7) 0	(28.7) 0	(45.3) 0	(38.6) 0	(38.6) 0	(57.9) 0	(46.3) 0	(46.5) 0	(161.1) 0	(161.1) 0	(161.1) 0
2	1.1	0.8	0	10.6	1.8	0.5	16.3	2.9	1.6	20.6	5.2	2.4	22.3	4.3	6.7	27.8	7.7	4.2	48.5	30.3	15.1
4	1.9	1.4	0.8	10.9	6.0	3.5	21.9	8.2	5.1	20.3	11.9	5.8	31.0	14.1	9.0	35.2	13.7	3.4	27.4	30.6	18.5
12	5.2	0.8	0.8	13.9	8.7	8.7	25.0	14.7	17.7	33.5	16.8	16.1	41.6	20.0	22.3	54.9	22.7	24.2	108.2	85.2	40.1
24	5.9	0.8	0.8	14.9	8.7	8.7	26.0	17.7	17.7	34.9	27.2	25.7	43.8	34.9	31.9	55.7	37.6	36.8	153.7	86.1	72.0

Headspace - 742.6 ml ( ) Avail O_2 Product - 125 gms.

Table 16. Oxygen Uptake of BEEF & RICE During Storage
(ml/125 gms. of product)

TIME WKS	30"			28"			26"			24"			22"			20"			0"		
	O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML			O_2 USED ML		
	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°
0	(1.8) 0	(1.5) 0	(1.5) 0	(13.2) 0	(9.6) 0	(9.6) 0	(22.6) 0	(19.1) 0	(19.1) 0	(32.0) 0	(30.2) 0	(30.2) 0	(41.9) 0	(39.2) 0	(39.2) 0	(52.0) 0	(48.3) 0	(48.3) 0	(157.0) 0	(157.0) 0	(157.0) 0
2	0	0	0	1.4	0	0	2.0	0.1	0	2.5	1.3	0.9	2.9	1.1	1.1	6.4	2.2	1.6	17.8	5.7	4.1
4	0.5	0	0	5.3	0.5	0.3	6.1	0	0	5.4	1.5	1.3	7.4	1.4	1.7	8.1	2.1	0.9	24.1	7.8	4.5
12	0	0.5	0	6.8	1.9	0	10.2	4.3	0.9	5.6	6.4	3.1	13.2	6.5	3.2	15.5	7.9	3.4	23.0	12.1	8.7
24	0.5	0.5	0	10.8	5.1	2.0	14.4	5.3	2.9	15.1	9.1	5.5	19.5	6.9	5.9	22.5	9.1	5.7	48.9	16.3	10.9

Headspace - 747.7 ml

( ) Avail O_2

Product - 125 gms.

Table 15. Oxygen Uptake of CHICKEN & RICE During Storage
(ml/125 gms. of product)

TIME	30"			28"			26"			24"			22"			20"			0"		
WKS	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°
0	(4.7) 0	(1.5) 0	(1.5) 0	(7.6) 0	(8.8) 0	(8.8) 0	(20.1) 0	(18.4) 0	(18.4) 0	(27.9) 0	(29.4) 0	(29.4) 0	(37.5) 0	(38.2) 0	(38.2) 0	(47.0) 0	(47.0) 0	(47.0) 0	(154.4) 0	(154.4) 0	(154.4) 0
2	2.0	0.0	0.0	2.0	0.7	0.0	6.5	0.0	0.0	7.2	2.2	0.7	8.0	2.2	1.4	10.2	0.7	0.0	49.6	3.0	1.4
4	2.5	0.8	0.0	4.5	1.4	0.0	11.0	2.2	0.0	13.1	4.4	2.2	16.3	4.4	2.9	18.6	2.2	1.4	40.8	4.5	2.3
12	0	0.8	0.0	3.0	2.2	1.4	13.2	2.2	0.0	23.2	5.9	1.5	30.0	5.1	2.2	38.6	4.4	0.0	137.3	8.1	3.7
24	3.5	0.8	0.0	6.1	3.7	2.2	18.3	4.4	1.5	25.5	7.3	3.7	33.4	6.6	2.9	44.1	8.8	3.6	146.3	16.2	7.4

Headspace Vol. - 735 ml   ( ) Avail O_2 Product - 125 gms.

Table 16. Oxygen Uptake of CHICKEN STEW During Storage
(ml/125 gms. of product)

TIME	30"			28"			26"			24"			22"			20"			0"		
WKS	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°
0	(8.7) 0	(1.47) 0	(1.47) 0	(15.6) 0	(7.35) 0	(7.35) 0	(21.0) 0	(16.32) 0	(16.32) 0	(35.0) 0	(27.34) 0	(27.34) 0	(46.3) 0	(36.90) 0	(36.70) 0	(54.4) 0	(46.60) 0	(46.60) 0	(151.1) 0	(151.1) 0	(151.1) 0
2	5.6	0	0	3.1	0.2	0	4.8	0	0	8.8	0.3	0.4	10.3	6.2	0	16.3	1.3	0.4	24.1	0.1	0
4	3.6	0	0	11.0	0.6	0.2	8.9	0.2	0	16.5	0	0	20.3	0.9	0	19.1	2.1	0	32.8	3.1	0
12	8.0	1.5	0.8	12.5	3.7	2.0	12.7	3.8	0	19.6	4.8	1.6	26.1	8.2	0.9	29.8	9.1	1.0	56.1	12.9	4.1
24	8.7	0.7	0.0	16.9	3.7	0.8	21.0	5.3	0.1	34.3	8.9	2.3	38.9	10.4	2.4	55.7	12.1	2.6	163.0	24.7	10.0

Headspace - 735 ml

( ) Avail O_2

Product - 125 gms.

Table 17. Oxygen Uptake of CHILI CON CARNE During Storage
(ml/125 gms. of product)

TIME WKS	30"			28"			26"			24"			22"			20"			0"		
	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°
0	(8.4) 0	(1.77) 0	(1.77) 0	(9.4) 0	(4.87) 0	(4.87) 0	(24.9) 0	(15.04 0	(15.04) 0	(36.3) 0	(24.43) 0	(24.48) 0	(48.7) 0	(34.22) 0	(34.22) 0	(53.5) 0	(43.51) 0	(43.51) 0	(154.9) 0	(154.9) 0	(154.9) 0
2	3.8	0	0	2.9	0.2	0	3.7	1.0	0.1	9.5	1.8	0	0.5	1.3	0.6	8.5	1.8	0	21.0	3.9	2.5
4	3.5	0	0	2.3	0.3	0	7.3	1.6	1.3	8.7	2.4	0	8.7	3.1	2.5	10.3	4.6	4.3	29.5	6.9	3.3
12	0.9	0.3	0	2.2	1.2	0.5	14.3	8.4	2.5	16.6	12.7	4.6	20.7	16.5	7.7	17.8	19.9	9.6	62.1	37.7	25.1
24	4.6	0	0.3	6.6	0	1.2	20.9	9.8	7.6	28.0	14.2	14.2	30.0	18.7	18.0	36.7	23.2	21.0	88.7	47.2	45.0

Headspace Vol - 737.4 ml

( ) Avail O_2

Product - 125 grams

Table 18. Oxygen Uptake of PORK WITH POTATOES During Storage
(ml/125 gms. of product)

TIME	30"			28"			26"			24"			22"			20"			0"		
WKS	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	40°
0	(2.9) 0	(0.8) 0	(0.8) 0	(6.9) 0	(5.3) 0	(5.3) 0	(17.6) 0	(15.1) 0	(15.1) 0	(31.7) 0	(25.6) 0	(25.6) 0	(43.0) 0	(35.4) 0	(35.4) 0	(52.5) 0	(43.0) 0	(43.0) 0	(158.4) 0	(158.4) 0	(158.4) 0
2	0.1	0.0	0.0	4.2	0.0	0.0	9.6	0.0	0.0	16.2	0.7	0.0	21.1	3.0	0.0	22.9	2.3	0.0	42.1	11.4	3.8
4	1.7	0.0	0.0	6.1	1.5	0.0	14.3	1.5	0.0	31.4	7.5	0.9	39.4	10.5	2.2	47.4	8.4	1.5	147.5	23.4	9.8
12	1.7	0.0	0.0	4.6	3.8	0.8	16.1	12.8	2.3	29.9	21.1	1.5	40.6	28.6	3.7	50.1	34.0	3.0	150.1	122.2	15.1
24	2.1	0.0	0.0	6.1	4.5	3.8	16.7	13.6	6.1	30.0	24.1	12.8	40.7	32.4	14.3	50.1	37.7	15.9	157.5	146.3	40.8

Headspace Vol - 754.1 ml

( ) Avail O_2

Product - 125 grams

Table 19. Oxygen Uptake of SPAGHETTI W/MEAT SAUCE During Storage
(ml/125 gms. of product)

TIME	30"			28"			26"			24"			22"			20"			0"		
WKS	100°	70°	40°	100°	70°	40°	100°	70°	40°	100°	70°	60°	100°	70°	40°	100°	70°	40°	100°	70°	40°
0	(6.9) 0	(7.5) 0	(7.5) 0	(11.7) 0	(7.8) 0	(7.8) 0	(19.7) 0	(18.8) 0	(18.8) 0	(28.6) 0	(29.6) 0	(29.6) 0	(38.3) 0	(38.4) 0	(38.4) 0	(45.5) 0	(46.8) 0	(46.8) 0	(157.0) 0	(157.0) 0	(157.0) 0
2	3.0	0	0	5.6	0	0	4.1	0.3	0	3.9	2.1	1.9	6.5	3.6	0.1	4.7	1.5	0.7	43.5	9.4	2.8
4	1.5	0	0	0	0.6	0	3.6	4.1	2.5	7.1	4.5	3.1	7.8	5.2	2.4	10.1	5.1	1.9	61.0	22.7	8.5
12	3.2	0	0	6.2	2.4	0.3	10.9	8.3	2.1	15.1	13.8	12.9	17.7	17.6	8.5	22.3	21.7	9.4	143.0	95.5	32.9
24	5.7	6.0	6.0	9.5	6.3	3.0	17.2	13.1	8.0	23.8	19.9	13.8	33.4	22.9	16.6	39.4	30.1	20.5	146.5	147.6	145.8

Headspace Vol - 747.6 ml

( ) Avail O_2

Product - 125 grams

Table 20. Analysis of variance and components of variance for oxygen uptake

FACTOR	Beef Hash		Beef Stew		Beef w/Rice		Chicken and Rice		Chicken Stew		Chili Con Carne		Pork with Potatoes		Spaghetti with Meat Sauce	
	Sig$^{(1)}$	%$^{(2)}$	Sig$^{(1)}$	%$^{(2)}$	Sig$^{(1)}$	%$^{(2)}$	Sig$^{(1)}$	%$^{(2)}$	Sig$^{(1)}$	%$^{(2)}$	Sig$^{(1)}$	%$^{(2)}$	Sig$^{(1)}$	%$^{(2)}$	Sig$^{(1)}$	%$^{(2)}$
Vacuum - A	xx	30.3	xx	40.5	xx	22.1	xx	16.8	xx	11.6	xx	30.1	xx	37.3	xx	44.3
Temp - B	xx	8.4	xx	12.5	xx	22.3	xx	23.4	xx	30.4	xx	14.8	xx	14.6	xx	2.7
Time - C	xx	15.1	xx	16.5	xx	14.6	xx	3.7	xx	8.7	xx	20.4	xx	6.9	xx	14.4
AB	xx	13.1	xx	6.1	xx	30.8	xx	36.1	xx	16.8	xx	7.2	xx	18.2	xx	4.0
AC	xx	30.8	xx	16.2	xx	2.7	n.s.	-	x	6.5	xx	19.0	xx	9.8	xx	28.4
BC	xx	2.1	n.s.	-	xx	6.6	x	4.6	xx	9.2	xx	5.8	x	3.0	n.s.	-
REM	-	0.2	-	8.2	-	0.9	-	15.4	-	16.8	-	2.7	-	10.2	-	6.2

(1) Significance xx - Significant at the 1% level
x - Significant at the 5% level
n.s.- Not significant at the 5% level

(2) Percent of variance

Table 20A. Combined Percentages Components of Variance

A + B + AB	51.8	59.1	75.2	76.3	59.0	52.1	70.1	51.0
A + C + AC	76.2	73.2	39.4	20.5	26.8	69.5	54.0	87.1
B + C + BC	25.6	29.0	44.5	31.7	48.3	41.0	24.5	17.1

Table 21. Percentage of oxygen available taken up by product packed in air and held 24 weeks

Product	Temperature		
	100°F.	70°F.	40°F.
Beef Hash	31	10	7
Beef Stew	83	65	17
Beef with Rice	95	53	45
Chicken and Rice	94	11	5
Chicken Stew	95	16	7
Chili Con Carne	57	31	29
Pork with Potatoes	99	92	26
Spaghetti with Meat Sauce	93	94	93

Table 22. Multiple Regression Equations with Oxygen Available, Temperature, and Time as Independent Variables and Oxygen Uptake as the Dependent Variable

Product	Coefficients R_{123}	Equation*
Beef and Rice	0.7870	$Y = 0.07X_1 + 0.11X_2 + 0.39X_3 - 9.30$
Beef Hash	0.7348	$Y = 0.19X_1 + 0.18X_2 + 0.98X_3 - 19.14$
Beef Stew	0.7878	$Y = 0.26X_1 + 0.22X_2 + 1.33X_3 - 21.14$
Chicken and Rice	0.6123	$Y = 0.18X_1 + 0.32X_2 + 0.64X_3 = 27.00$
Chicken Stew	0.6680	$Y = 0.13X_1 + 0.29X_2 + 0.74X_3 = 23.84$
Chili Con Carne	0.7916	$Y = 0.15X_1 + 0.12X_2 + 0.87X_3 = 14.03$
Pork with Potatoes	0.7295	$Y = 0.36X_1 + 0.39X_2 + 1.20X_3 = 36.13$
Spaghetti with Meat Sauce	0.7599	$Y = 0.38X_1 + 0.17X_2 + 1.45X_3 = 26.68$

*
X_1 = Oxygen available in ml/125 gms. product (0 to 160 ml)
X_2 = Temperature in °F. (40 to 100°F)
X_3 = Time in weeks (0 to 24)
Y = Oxygen uptake in ml/125 gms. product

Table 23. Correlation coefficients (r) for time vs. log mol fraction of oxygen remaining at three temperatures

Product	r		
	100°F.	70°F.	40°F.
Beef Hash	0.741	0.672	0.669
Beef Stew	0.916	0.659	0.738
Beef with Rice	0.680	0.761	0.734
Chicken and Rice	0.855	0.449	0.540
Chicken Stew	0.876	0.761	0.201
Chili Con Carne	0.846	0.624	0.841
Pork with Potatoes	0.541	0.824	0.733
Spaghetti with Meat Sauce	0.863	0.854	0.686

Significance at 5 percent level r = 0.367

Significance at 1 percent level r = 0.470

DF = 27

References

1. Bishov, S. J. and A. S. Henick. 1966. A gas chromatograph method for continuous accelerated study of O_2 uptake in fats. J. Am. Oil Chemists' Soc. 43, 477.

2. Hanson, S. W. F. (ed.). 1961. The Accelerated Freeze-Drying Method of Food Preservation. H. S. Stationery Office, London.

3. Harper, S. C. and A. L. Tappel. 1957. Advances in Food Research. 7, Academic Press, New York.

4. Hicks, C. R. 1956. Fundamentals of analysis of variance. Part II. The components of Variance Model and the Mixed Model. Ind. Qual. Control. 13 (No. 3), 5.

5. Olcott, Harold S. 1962. Deteriorative reactions in stored freeze-dried meat and fish, in "Freeze-Drying of Foods." (F. R. Fisher, ed.), National Academy of Sciences - National Research Council, Washington, D. C.

6. Roth, N., R. Wheaton, and P. Cope. 1965. Effect of exposure to oxygen on changes in meats and vegetables during storage. Contract No. DA19-129-AMC-131 (N), U. S. Army Natick Laboratories.

7. Sharp, J. G. 1953. Dehydrated Meat. H. M. Stationery Office, London.

8. Smithies, W. R. 1962. The influence of processing conditions on the rehydration of foods, in "Freeze-Drying of Foods." (F. R. Fisher, ed.), National Academy of Sciences - National Research Council, Washington, D. C.

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Natick, MA 01760

13. ABSTRACT

Eight freeze-dried combination meat items used as main components in the Food Packet, Long Range Patrol were packed with different amounts of oxygen in the headspace gas and stored at 100°, 70°, 40°F. with withdrawals at 0, 2, 4, 12 and 24 weeks. The eight items were beef hash, beef stew, beef with rice, chicken and rice, chicken stew, chili con carne, pork with potatoes, and spaghetti with meat sauce. Oxygen uptake was determined. With the product stored at 100°F., the product was also evaluated by a 10-member technological panel and the rehydration ratio determined.

Regression analysis showed that flavor and odor correlated highly with oxygen uptake and the slopes of the regression lines were almost identical for the eight items. No correlation was found between rehydration ratio and oxygen uptake. Analysis of variance indicated that vacuum, temperature and time had significant effects on oxygen uptake, but the relative importance of temperature and time was different for different products. Multiple linear regression equations were derived using oxygen available, temperature, and time as independent variables and oxygen uptake as the dependent variable. The multiple correlation coefficients ranged between 0.61 and 0.79. Highly significant linear correlation coefficients were found with the regression of time on log mol fraction of oxygen remaining. This indicates that the oxygen uptake reactions have attributes of a first order reaction.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Oxygen	6		5			
Freeze dried foods	7		9			
Meat	7		9			
Storage stability	7		8			
Food packaging	4		4			
Temperature	6		5			