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TECHNICAL REPORT
75-20-FEL

STORAGE STABILITY OF ROASTED, THIN-SLICED, FREEZE-DRIED BEEF

by

Larry C. Hinnergardt

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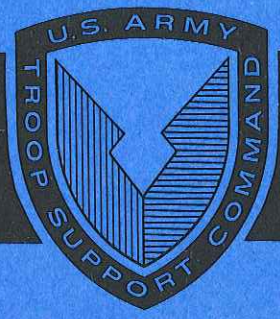
August 1974

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760



Food Engineering Laboratory
FEL-5

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ABSTRACT

The semimembranosus muscle was excised from six US Good Grade top rounds. The excised muscles were trimmed into roasts that were 7.6 X 12.7 X 20.3cm in size. The roasts were stuffed into artificial casings, randomized, and oven-roasted to internal temperatures of 60, 65.5 or 71.1°C. The roasts were cooled to 4.4°C and sliced 1.6mm thick. The slices were frozen at -23.3°C and freeze-dried with a plate temperature of 51.6°C and a chamber pressure of 0.3 (0.040 k Pa) to 0.5 (0.06 k Pa) mm Hg vacuum. The dry material was vacuum-packed and stored at regular intervals (initial 2, 4, 8, 12 and 24 weeks) and evaluated for color, odor, flavor, texture and appearance by a technological taste panel. While high storage temperature and longer storage times had a definite effect on product quality, all samples were considered to be of acceptable quality. The samples with the best texture, flavor, color and appearance after six months of storage at 28°C were those prepared from roasts cooked to an internal temperature of 60°C.

INTRODUCTION

Unrefrigerated storage is one of many advantages of freeze-dried foods. Thomson et al. (1962), Tuomy et al. (1960) and (1970) agree that storage stability of freeze-dried foods depends on percent moisture in the samples, absorption of oxygen and the storage temperature. Tuomy et al. (1969) and (1970) concluded that oxygen and moisture contents under 2% usually resulted in acceptable freeze-dried product after six months of storage at 4.4, 25 and 38°C. However, Tuomy et al. (1969) noted considerable variation among products studied as to their oxygen uptake at different storage temperatures and storage periods.

Thomson et al. (1962) found .63cm thick x 1.90cm diameter beef disks not only took up less water after storage, but took up the water at a reduced rate. Deterioration of texture was continous throughout storage. The best samples were those of 1.7% moisture and -17.8°C storage which resembled fresh meat upon rehydration. Samples stored at 32.2°C exhibited a dry, cellulose sponge-like texture. They concluded that of the factors studied, storage temperature was the largest contributor to deterioration of freeze-dried beef, moisture contents above 2% also contributed to less desirable characteristics of freeze-dried beef. Heldman et al. (1973) also found a hardening effect in freeze-dried beef over a six-months storage period. The hardening effect was dependent on the storage temperature of 38°C.

A roasted, thin sliced (1.6mm), freeze-dried beef product which demonstrated instant rehydration and a texture very similar to roasted thin sliced beef was described by Hinnergardt and Burger (1974). This product represents a great improvement on previous precooked freeze-dried beef; however, its ultimate utility depends on its storage life when packed using commercially accepted practices for freeze-dried foods. Consequently, this study was initiated to determine the effect of internal roasting temperature, storage temperature and storage time on the texture, flavor, odor, color and appearance of roasted thin sliced beef.

MATERIALS AND METHODS

Six fresh US Good Grade top rounds were obtained commercially from local suppliers. The semimembranosus muscle was excised and trimmed to produce roasts that were 7.6 x 12.7 x 20.3cm in size. The roasts were then put into artificial casings to prevent excess moisture loss during oven roasting. The casing, while not tight, was tight enough to make firm contact with the muscle to be cooked. The encased roasts were roasted in a rotary hearth oven at 136°C. Roasts were randomly selected to be removed from the oven when their internal temperatures reached 60, 65.5 and 71.1°C respectively.

The cooked roasts were allowed to cool to an internal temperature of 4.4°C prior to slicing. The meat was cut across the grain into 1.6mm slices. Each roast produced approximately 55 slices.

The beef was freeze-dried using a plate temperature of 51.6°C and a chamber pressure of 0.3 (0.040 kPa) to 0.5mm Hg (0.067 kPa) vacuum. The final moisture content of the product was less than 2%. The cooked, thin-sliced beef was canned under 709 mm vacuum (6.5 kPa) after being flushed twice with nitrogen to produce a headspace oxygen content of less than 1%. The canned samples were stored at 4.4 and 38°C for 6 months. The withdrawal periods were as follows: initial, 2 4, 8, 12 and 24 weeks.

At each withdrawal period the dry beef was rehydrated by submerging the cooked, thin-sliced, freeze-dried beef into 60°C water for 20 seconds. The excess water was allowed to drip from the slices prior to serving. The rehydrated slices were evaluated by a 10-member organoleptic panel for flavor, texture, color, odor and appearance. Evaluation was based on a 1 to 9-point rating scale (1 - extremely poor; 9 = excellent). Data was analyzed by means of an Analysis of Variance and the Newman-Keuls multiple range test.

RESULTS AND DISCUSSION

Precooked, thin-sliced, freeze-dried beef prepared from roasts cooked to an internal temperature of 60°C were preferred over those prepared from roasts cooked to internal temperatures of 65.5 and 71.1°C for all characteristics studies (Table 1). Even though the slices from the 60°C were preferred, all slices would be considered acceptable for military survival rations.

The large initial flavor differences between samples due to internal roast temperatures of the slice were moderated by storage time within storage temperatures (Table 5). Thus, at the end of 24 weeks, the flavor differences were associated with storage temperatures rather than the internal cook temperature of the roast. In contrast to flavor, the higher sensory scores for the precooked, thin-sliced freeze-dried beef for texture, color and appearance (Tables 4, 6, and 8) noted initially were maintained throughout the 24 weeks of storage at 38°C. The differences in color and appearance attributed to internal cooking temperature are minimal for samples stored at 4.4°C for 24 weeks.

Samples stored at 4.4°C were significantly different ($P<.01$) in flavor, texture, color, odor and appearance from those stored at 38°C (Table 2). These results agree with Thomson et al. (1962) and Heldman et al. (1973).

The holding time at a given internal temperature was not included in this study since holding time was not found to be an important factor in acceptability of precooked, thin-sliced beef (Hinnergardt and Burger, 1974). The 82.2°C internal cooking temperature eliminated from the experiment because earlier work at Natick Labs indicated that slices prepared from roasts cooked to an internal temperature of 82.2°C rated lower in flavor, color and appearance than those prepared at 60°C and 71.1°C internal cooking temperature. Consequently, an intermediate internal cooking temperature of 65.5°C was included to help elucidate differences between 60 and 71.1°C.

The storage time (Table 3) affected the flavor, texture, color, odor and appearance of the precooked, freeze-dried beef. These results confirmed the earlier findings of Tuomy, et al. (1969) and Thomson (1962). It is interesting to note that the statistical significant break occurs between 4 and 8 weeks in the deterioration of flavor, texture, color and appearance of roasted, thin-sliced, freeze-dried beef. Once the significant drop in the sensory characteristics occured, the ratings remained constant for the remainder of the storage period.

CONCLUSIONS

A 38°C storage temperature results in a significant decrease in the organoleptic properties of roasted, thin-sliced freeze-dried beef.

Storage time exhibits a deleterious effect on roasted, thin-sliced, freeze-dried beef.

An internal roast temperature of 60°C produced a more desirable texture, flavor, color and appearance of roasted, thin-sliced freeze-dried beef after six months of storage at 38°C.

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Table 1. The effect of internal cooking temperature on the flavor, texture, color, odor, and appearance of rehydrated freeze-dried beef slices stored for 6 months at 4.4 and 38°C.[1]

	Internal Roast Temperature		
	60°C	65.5°C	71.1°C
Texture	6.47[a]	5.70[b]	5.69[b]
Flavor	6.00[a]	5.67[a]	5.72[a]
Color	6.43[a]	5.76[b]	5.83[b]
Odor	5.90[d]	5.58[e]	5.44[e]
Appearance	6.38[a]	5.80[b]	5.88[b]

[1] Texture, Flavor, color, odor and appearance were rated on a one to nine scale (1=extremely poor; 9=excellent).

[a,b] Means with unlike superscripts are different ($P < .01$).

[d,e] Means with unlike superscripts are different ($P < .05$).

Table 2. The effect of storage temperature on the flavor, texture, color, odor and appearance of rehydrated freeze-dried beef slices stored for 6 months at 4.4 and 38°C.[1]

	STORAGE Temperature	
	4.4°C	38°C
Flavor	6.11[a]	5.48[b]
Texture	6.31[a]	5.60[b]
Color	6.22[a]	5.79[b]
Odor	5.79[a]	5.49[b]
Appearance	6.26[a]	5.79[b]

[1] Flavor, texture, color, odor and appearance were rated on a one to nine scale (1=extremely poor; 9=excellent).

[a,b] Means with unlike superscripts are different ($P < .01$).

Table 3. The effect of storage time on flavor, texture, color, odor and appearance of rehydrated,[1] freeze-dried beef slices stored for 6 months at 4.4 and 38 °C.

	Storage Time[2]					
	0	2	4	8	12	24
Flavor	6.63^{a}	6.20^{ab}	5.82^{bc}	5.43^{c}	5.38^{c}	5.32^{c}
Texture	6.53^{a}	6.10^{a}	6.17^{a}	5.65^{b}	5.63^{b}	5.63^{b}
Color	6.53^{a}	6.35^{ab}	5.95^{b}	5.83^{bc}	5.63^{c}	5.78^{bc}
Odor	5.80^{ab}	6.07^{a}	5.40^{ab}	5.57^{b}	5.40^{b}	5.62^{ab}
Appearance	6.53^{a}	6.32^{ab}	5.97^{bc}	5.92^{bc}	5.65^{c}	5.75^{c}

[1] Flavor, texture, color, odor and appearance were rated on a one to nine scale (1=extremely poor; 9=excellent).

[a,b,c] Means with unlike superscripts are different ($P < .05$).

Table 4. Texture of freeze-dried beef slices stored for 6 months at 4.4 and 38°C. [1]

Internal Roast Temperature	Storage Temperature	Storage time (weeks) 0[e]	2[e]	4[e]	8[f]	12[f]	24[f]
60°C[a]	4.4°C[c]	7.2	7.0	6.9	6.7	6.5	6.7
	38.0°C[d]	7.2	6.3	6.6	5.5	5.9	5.8
65.5°C[b]	4.4°C[c]	6.4	6.6	6.4	5.8	6.0	6.0
	38.0°C[d]	6.4	5.4	5.8	5.2	4.6	5.0
71.1°C[b]	4.4°C[c]	6.0	6.5	6.4	5.7	5.8	6.1
	38.0°C[d]	6.0	5.8	5.0	4.9	5.0	4.9

[1] Texture rated on a one to nine scale (1=extremely poor; 9=excellent).
a,b Internal roast temperatures with unlike superscripts are different ($P<.05$).
c,d Storage temperatures with unlike superscripts are different ($P<.01$).
e,f Storage time with unlike superscripts are different ($P<.05$).

Table 5. Flavor of freeze-dried beef slices stored for 6 months at 4.4 and 38°C.

Internal Roast Temperature N.S.	Storage Temperature	Storage Time (weeks) 0[c]	2[c,d]	4[d,e]	8[e]	12[e]	24[e]
60°C	4.4°C[a]	7.2	6.4	6.6	6.6	5.9	5.7
	38.0°C[b]	7.2	6.3	6.0	5.0	5.1	5.0
65.5°C	4.4°C[a]	6.6	6.2	5.7	5.7	6.0	6.0
	38.0°C[b]	6.6	5.4	5.9	5.2	4.1	4.5
71.1°C	4.4°C[a]	6.2	6.6	5.7	5.8	5.8	5.9
	38.0°C[b]	6.2	6.2	5.4	5.1	5.2	5.0

[1] Flavor rated on a one to nine scale (1=extremely poor; 9=excellent).
N.S. Non-significant differences among internal roast temperatures ($P<.05$).
a,b Storage temperatures with unlike superscripts are different ($P<.01$).
c,d,e Storage times with unlike superscripts are different ($P<.05$).

Table 6. Color of freeze-dried beef slices stored for 6 months at 4.4 and 38°C.

Internal Roast Temperature	Storage Temperature	Storage time (weeks) 0[e]	2[e,f]	4[f]	8[f,g]	12[g]	24[f,g]
60°C[a]	4.4°C[c]	6.9	7.0	6.8	6.9	6.6	5.9
	38.0°C[d]	6.9	6.3	6.5	5.4	5.8	6.2
65.5°C[b]	4.4°C[c]	6.5	6.2	5.8	5.9	5.4	6.0
	38.0°C[d]	6.5	6.0	5.6	5.6	4.9	4.7
71.1°C[b]	4.4°C[c]	6.1	6.4	5.7	5.8	5.7	6.4
	38.0°C[d]	6.1	6.2	5.3	5.4	5.4	5.5

[1] Color rated on a one to nine scale (1=extremely poor; 9=excellent).
a,b Internal roast temperatures with unlike superscripts are different ($P < .05$).
c,d Storage temperatures with unlike superscripts are different ($P < .01$).
e,f,g Storage times with unlike superscripts are different ($P < .05$).

Table 7. Odor of freeze-dried beef slices stored for 6 months at 4.4 and 38°C.

Internal roast temperature	Storage temperature	Storage time (weeks) 0[e,f]	2[e]	4[e,f]	8[f]	12[f]	24[e,f]
60°C[a]	4.4°C[c]	6.5	6.2	6.0	6.0	5.9	5.3
	38.0°C[d]	6.5	6.2	6.0	5.1	5.5	5.6
65.5°C[a,b]	4.4°C[c]	5.6	6.1	5.5	5.9	5.8	6.0
	38.0°C[d]	5.6	6.1	5.6	5.3	4.7	4.9
71.1°C[b]	4.4°C[c]	5.3	6.2	5.5	5.3	5.3	5.2
	38.0°C[d]	5.3	5.9	4.8	5.3	5.2	5.5

1. Odor rated on a one to nine scale (1 = extremely poor, 9 = excellent).
a,b Internal roast temperatures with unlike superscripts are different ($P < .05$).
c,d Storage temperatures with unlike superscripts are different ($P < .05$).

Table 8. Appearance of freeze-dried beef slices stored for 6 months at 4.4 and 38°C.

Internal Roast temperature	Storage temperature	Storage time (weeks) 0[e]	2[a,f]	4[f,g]	8[f,g]	12[g]	24[g]
60°C[a]	4.4°C[c]	7.0	7.0	6.6	7.0	6.2	6.0
	38.0°C[d]	7.0	6.6	6.5	5.7	5.2	5.8
65.5°C[b]	4.4°C[c]	6.5	6.2	5.9	5.9	5.8	5.9
	38.0°C[d]	6.5	5.8	5.7	5.6	5.9	4.8
71.1°C[b]	4.4°C[c]	6.1	6.3	5.8	5.7	6.1	6.6
	38.0°C[d]	6.1	6.0	5.3	5.5	5.6	5.4

1. Appearance rated on a one to nine scale (1 = extremely poor; 9=excellent.)
a,b Roasting temperatures with unlike superscripts are different ($P \leq .01$).
c,d Storage temperatures with unlike superscripts are different ($P < .01$).
e,f,g Storage times with unlike superscripts are different ($P < .05$).