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THE EFFECT OF SEVERAL ANTIOXIDANTS ON THE STORAGE STABILITY OF DEHYDRATED POTATO FLAKES[1]

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ABSTRACT

Two types of potato (Clone 709 and cultivar Russet Burbank) were processed to mash, treated with two propietary antioxidants, Tenox 20 and Tenox 26, and dried on a small double-drum drier to produce dehydrated mashed potatoes. The potato flakes were packed in nitrogen or air and stored at two different storage temperatures, 21±2° and 37±1°C , for 16-18 wk. Gas-liquid chromatographic analysis of the two potato samples showed a higher percentage of unsaturated fatty acids in Clone 709 than Russet Burbank. Lipid oxidation and non-enzymatic browning were determined initially and during storage. Storage at 21±2°C in the absence of atmospheric oxygen resulted in less autoxidation and less browning of the dried flakes. Samples containing antioxidant were also superior to the controls. Tenox 26 improved the shelf-life of both types potato flakes throughout the storage period; samples containing Tenox 20 were less stable. A notable browning was demonstrated in air or nitrogen packed samples of Clone 709. No browning was observed in flakes prepared from Russet Burbank potatoes during 16-18 wk of storage.

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اثر چند ماده ضد اکسیداسیون در طول عمر انبارداری و کیفیت پوره خشک سیب زمینی

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خلاصه

دورقم سیب زمینی (کلون۷۰۹ ورقم راست بوربانک) بطورجداگانه پس ازپختن وخمیرکردن واضافه نمودن دوماده ضداکسیداسیون بنام تیناکس ۲۰ وتیناکس ۲۶ روی یک دستگاه خشک کن غلطکی بصورت پوره خشک درآورده شدند. محصول خشک شده درازت یا هوا ودر حرارت های ۲± ۲۱ و۱ ± ۳۷ درجه سانتیگراد درقوطی های حلبی بسته بندی وانبار گردیدند. نتایج کروماتوگراف گازمایعی نشان دادکه درچربی آنها مقدارقابل توجهی ازاسیدهای چرب اشباع نشده موجودمیباشد. اکسیداسیون وقهوه ای شدن غیرآنزیمی از ابتدا تا انتهای انبارداری اندازه گیری گردیدونشان داده شدکه محصول خشک درحرارت ۲۱ درجه سانتیگراددودرازت مقدارناچیزی ازاین فسادهای شیمیائی باقی میگذاردو استفاده ازتیناکس ۲۶ درطول انبارداری نتایج بهتری بدست میدهد. درمحصول خشک کلون ۷۰۹ قهوه ای شدن غیرآنزیمی قابل ملاحظه ای مشاهده گردیددرحالیکه پوره خشک سیب زمینی راست بوربانک درطول انبارداری هیچگونه علائم قهوه ای شدن نشان نداد.

INTRODUCTION

A complex series of non-enzymatic reactions may occur during processing and storage of food products and cause deterioration of flavor and nutritional value of foods (5, 10).

The process of the spontaneous reaction between atmospheric oxygen and many types of organic compounds is referred to as autoxidation. Rancidification or off-flavor of many fats and fat containing materials is due to autoxidation (7).

Browning and lipid oxidation deterioration in mashed potato powder in certain storage conditions were reported by Burton (6, 7). The development of brown color and off-flavor have been ascribed to non-enzymatic browning. Off-flavors have also been described as rancid, stale or haylike; and these may be due to autoxidation of unsaturated potato lipids. It has been shown (15) that the shelf-life of potato flakes is limited due to development of haylike off-flavors associated with oxidative reaction. The use and determination of anti-oxidants in dehydrated mashed potatoes are important for the product shelf-life (3).

The purpose of this study was to determine the extent of lipid autoxidation and non-enzymatic browning in two types of dehydrated mashed potatoes containing antioxidants and stored

at two temperatures in air or nitrogen.

MATERIALS AND METHODS

Raw material

The potato samples, Clone 709 and cultivar Russet Burbank were obtained from the Department of Crops and Soil Science at Michigan State University. Potatoes were preconditioned at 18.3°C and 90-95% RH for three weeks before processing.

Processing Procedures

Potatoes were washed, preheated, and peeled in 12-15% hot lye solution. The peels and lye were washed and the potatoes were cut into 9-mm slices with Qualhein slicer machine model 101, then transferred to 1000 ppm SO_2 solution. The slices were precooked for 20 min at 71-74°C and then cooled to 21.1-26.7° C in a cold water bath. After removal, they were allowed to stand for 20 min. The slices were cooked at 100° C for 30 min. and riced with an electric Hobart Kitchen model 3-C with a coarse rotary grater attachment. The additive mixture of either Tenox 20 or Tenox 26 antioxidants was prepared (1, 2) and added to each 4.5 kg mash in a Hobart mixer model A-200 and then thoroughly mixed. The controls contained all additives except Tenox antioxidants. The mash samples were dried on an Overton Machine Company model P-36 double drum drier, equipped with drums of 30 cm diameter and 47.8 cm length. One drum was kept unheated and used as an applicator roll. All samples were dried with 54842-56248 kg m^{-2} steam pressure in the drums and a 4.7 cm nip between rolls. However, different drum speeds and doctor-blade simulations were used. For Clone 709 samples, the drum speed was 8 rpm and 4 layers of dried sheets were taken for each simulation, whereas for Russet Burbank, 6.5 rpm and 3 layers were used. The dried sheets were kept in moisture-proof plastic bags for 24-48 hr to equalize the moisture content and finally were comminuted to very small flakes with a comminuting

machine model D, using screen No. 2. Samples for nitrogen packing were canned in 8 oz No. 1 cans, then they were evacuated in a vacuum chamber at 73.75 cm of mercury with a water aspirator and were double gassed with pure nitrogen. The air packed samples were kept in 250 g glass jars covered with aluminum foil. All samples were stored at two different temperatures, 21±2°and 37±1°C for 18 wk and then removed for appropriate analysis.

Quantitative Analysis of Fatty Acids

Fatty acid methyl esters of the initial control samples were prepared by treatment of extracted fat samples with boron triflouride-methanol reagent (14). Methyl esters were chromatographed on a F & M model 810 gas chromatograph equipped with a dual flame ionization detection system. A stainless steel 300 x 0.31 cm column was packed with 20% stabilized diethylene glycol succinate on 80/100 mesh acid washed chromosorb W. The following conditions were used:

Injection port temperature, °C	270
Detection block temperature, °C	280
Hydrogen flow, ml min^{-1}	63
Air flow, ml min^{-1}	500
Nitrogen carrier gas flow, ml min^{-1}	25
Range setting	10^3
Attenuation lower limit	4
Column tempetrature, °C	190

Esters were indentified by a comparison of their retention time to a series of pure standard methyl esters (K & K Laboratories, Inc. Plain View, New York). Esters were quantitated by disk integration. Correction factors were derived as described by Bills *et al.* (4). The correction factors were based on the response of a given ester to that of the appropriate internal standard, Laurate: C_{12}. Standard fatty acids were obtained from the Hormel Foundation, Austin, Minnesota.

TBA Value Determination

A modification of the 2-thiobarbituric acid test which had been suggested for baked products by Caldwell and Grogg (8) was used to determine the extent of autoxidation. The test was run every two weeks for air packed and every month for nitrogen packed samples. TBA reagent was prepared as described by Kohn and Liversedge (13).

Non-enzymatic Browning Measurement

Browning of samples was measured with Hunter lab color difference meter model D-25 and Agtron-500. The results were obtained every two wk for air packed and once a month for nitrogen packed samples.

a) The Hunter was standardized with a yellow tile, color standard No. 2814 with L=83.0, AL=3.5, and b_L=26.5 at each trial. The samples were packed in the glass dishes and tapped gently to a depth that minimized light transmission. Two readings were taken on each sample and the average was computed.

b) The Agtron-500

The instrument was calibrated by standard reflectance disks at each trial. The disk range, 63-90 was chosen and the calibration was done so that the ranges were extended to between 0 and 100% spectral reflectance. The relative spectral reflectance was made directly after calibration in yellow color mode.

RESULTS AND DISCUSSION

Preconditioning of potatoes before processing was necessary to bring the reducing sugar content down to a level suitable for processing and storage stability. The potatoes used in this study had been taken from low storage temperature, 1.1°C. The sugar content of potateos are increased when they are stored at tempratures 1.1°-2.2° C (16, 18) and this condition may cause darkening of processed potato products.

Potatoes were kept in SO_2 solution (prepared from sodium bisulfate) after peeling and cutting to inhibit browning during processing. Non-fat dry milk was added to improve whiteness. Nyverol (Type 18-07) emulsifier was incorporated into the mash to improve texture, and also served as a convenient vehicle for adding antioxidant mixture. When antioxidants were used, either Tenox 20 or Tenox 26 (2) was adadded to the emulsifier and the mixture was blended into the mash.

The initial moisture content of the samples was between 6.6-7.9% which is somewhat high for optimal stability. Commercial dehydrated mashed potatoes contain about 5-6% moisture. Changes in moisture content occurring during storage were minimal.

The composition of the fatty acids in lipid material extracted from dried flakes is presented in Table 1. The percentage of total mixed fatty acids in the lipid extract was 53.1% for Russet Burbank and 54.9% for Clone 709. The data in Table 1 show that in Clone 709 the lipid material contained little or no oleic acid. However, a higher percentage of unsaturated fatty acids was obtained in this Clone than Russet Burbank and this might relate to storage stability of dried flakes. Significantly higher levels of linolenic acids were noted in Clone 709. High levels of unsaturation of fatty acids in potato cultivars would result in accumulation of off-flavors in dehydrated potato products (11).

The TBA values of the air-packed samples expressed as O.D. or absorbency are shown in Figs. 1 and 2. The higher the TAB value, the greater will be the degree of autoxidation. The nitrogen-packed samples exhibited very little change in autoxidation during storage, especially for the first 10-14 wk (Table 2) while there was a notable change in air-packed samples (Figs. 1 and 2). At the higher storage temperature of 37°C, the TBA values of both Clone 709 and

Table 1. Fatty acid composition in total mixed fatty acids of potato lipids.

Fatty acid	Correction factor	Percentage	
		Russet Burbank	709
Myristic, C14:0	0.9038	2.02	3.00
Palmitic, C16:0	0.8343	13.32	17.50
Stearic, C18:0	1.1233	54.34	51.50
Oleic, C18:1	1.6200	6.21	--
Linoleic, C18:2	1.1664	12.66	17.00
Linolenic, C18:3	1.2654	6.46	11.00

Russet Burbank indicated that extensive oxidation had occurred. Samples containing Tenox 20 and Tenox 26 antioxidants had good initial stability. These samples at room temperature were stabilized throughout the storage period, having lower TBA values than did the controls. Tenox 26 improved the storage stability of all samples through 12-wk storage; with longer storage all of the samples held at 37°C showed similar levels of oxidation. The rapid increase in autoxidation of Clone 709 samples is shown clearly in Fig. 1. It is seen that the TBA values of samples containing antioxidants are below the control values, except for Tenox 20 samples after the 10th week of storage.

Of the two cultivars processed, Clone 709 flakes showed higher initial TBA values (Figs. 1 and 2). The samples containing Tenox 20 stored air packed at 37°C oxidized to

Table 2. TBA values of dehydrated mashed potatoes during the storage, nitrogen packed, at 21±2° and 37±1°C.

Time (wk)	Absorbency at 532 nm					
	(Clone 709)					
	21±1°C			37±1°C		
	Control	+ Tenox 20	+ Tenox 26	Control	+ Tenox 20	+ Tenox 26
2	0.043	0.033	0.030	0.045	0.035	0.038
6	0.045	0.033	0.036	0.044	0.036	0.036
10	0.043	0.031	0.036	0.050	0.036	0.038
14	0.045	0.033	0.038	0.050	0.050	0.041
18	0.070	0.060	0.068	0.080	0.065	0.083
	(Russet Burbank)					
2	0.041	0.038	0.036	0.038	0.044	0.038
6	0.041	0.036	0.030	0.041	0.044	0.041
10	0.041	0.036	0.045	0.060	0.045	0.045
14	0.075	0.073	0.065	0.086	0.080	0.080
18	0.070	0.065	0.070	0.096	0.099	0.083

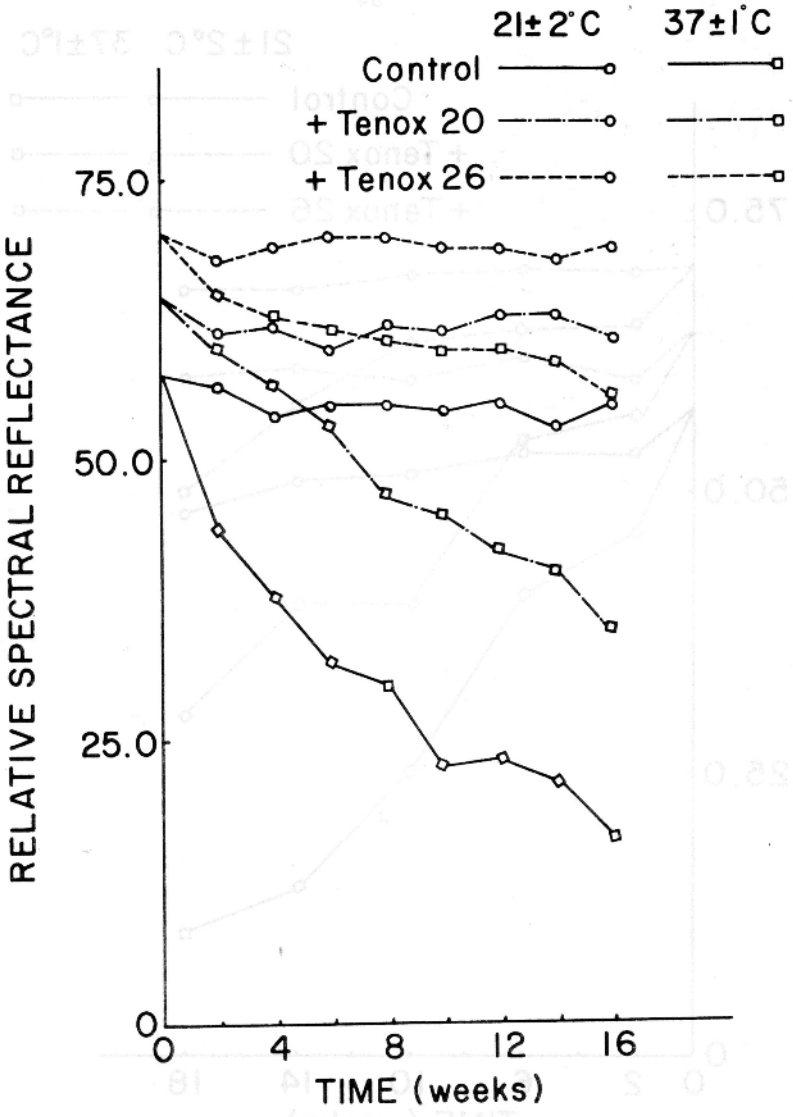

Fig. 1. Development of non-enzymatic browning in dehydrated mashed potatoes (Clone 709) during storage, air-packed, 21 and 37°C.

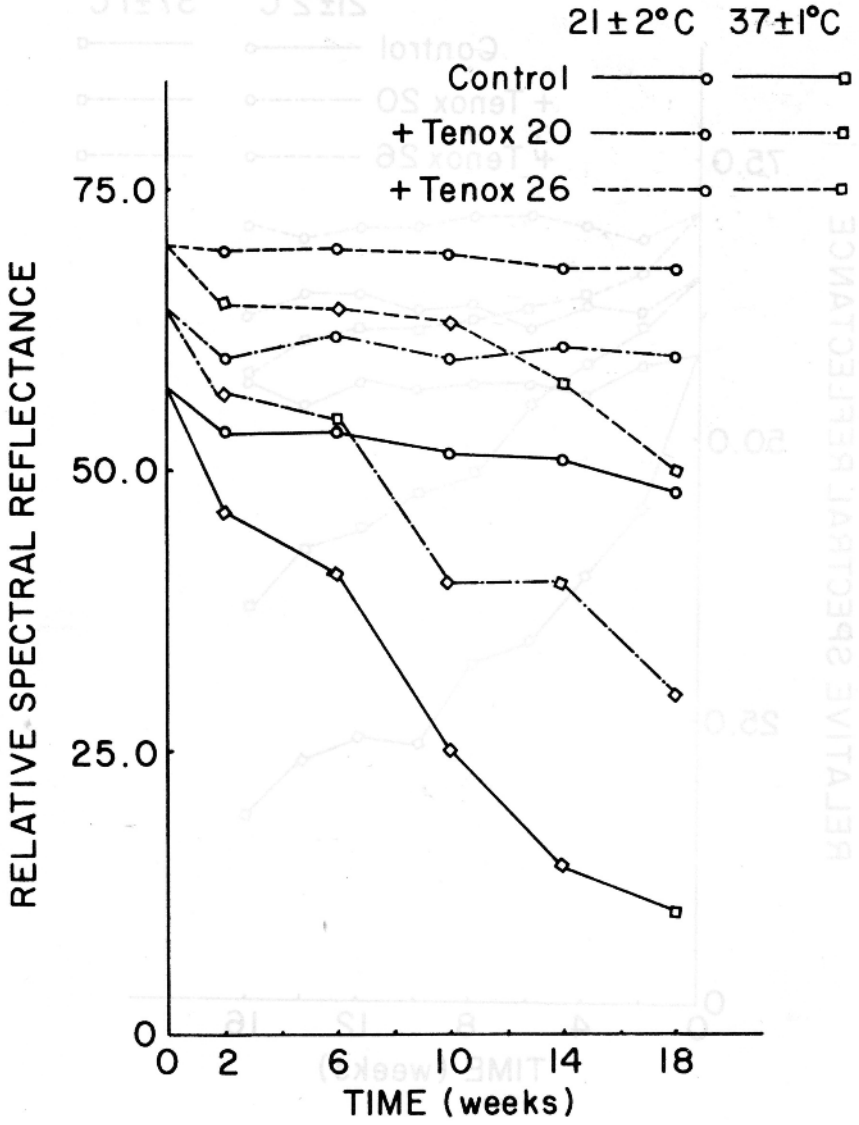

Fig. 2. Development of non-enzymatic browning in dehydrated mashed potatoes (Clone 709) during storage nitrogen-packed, 21 and 37°C.

a slightly greater extent than the controls, after 12 wk. It is apparent that little or no benefit was gained by incorporating the antioxidants in samples stored in air at 37° C, although some protection was offered by antioxidants up to 12 wk. However, storage of potato flakes at 37° C, air, is obviously not desirable.

In general, the storage stability of the nitrogen packed samples was superior to air-packed ones as measured by TBA values (Table 2). The beneficial effect of antioxidants is less evident in nitrogen packed samples.

Occasional decrease observed in TBA values (Figs. 1 and 2) is difficult to explain precisely but may possibly be related to a decrease in TBA reactive materials at that point in storage.

The color of the TBA reaction products was not stable after several hr, so that absorbancy had to be measured immediately after the reaction mixture was purified by column chromatography.

Tenox 26 had an excellent solubility in fats and oils (2). Tenox 26 contains BHA and BHT, both of which remain active in baked and fried foods (9). These might explain why the samples containing Tenox 26 antioxidants showed better stability than the samples with Tenox 20. In addition, Tenox 20 contains TBHQ which may have been volatilized during the process of drum drying or, less likely, during the storage at higher temperatures.

Both instruments used in the measurement of non-enzymatic browning provided information on browning in a direct and rapid measure. In the Hunter lab color difference meter, the reflected color of the sample is decomposed into three vectors: L which shows the lightness of the sample; a_L which shows the redness when (+) and greenness when (-); b_L which shows the yellowness when (+) and blueness when (-). With these three figures the extent of browning can be measured. On the other hand, the Agtron-500 instrument indicates the

relative spectral reflections of the samples, using standard reflectance disks with desired spectral range in a chosen colormode. These conditions were maintained throughout storage for all of the samples.

In Tables 3, 4, 5 and 6, the results of browning measurements with the Hunter lab color difference meter are shown. Notable browning is shown in both air-and nitrogen-packed in Clone 709 controls. This browning was observed at 4-6 wk storage at 37°C. L values decreased in about 4 units and also more redness was observed, especially in controls, by a notable increase in a_L values. The b_L values were also increased, except for samples containing Tenox 26, and showed more yellowness in the samples. Sample containing Tenox 20 exhibited distinct browning after 8-10 wk of storage at 37°C. Samples containing antioxidants and stored at 21°C were stabilized in color throughout storage and their browning reactions were much less than those held at higher storage temperature. Oxygen *per se* has no direct effect on non-enzymatic browning (Tables 3 and 4). No browning was observed in the Russet Burbank. There was only a small change in the samples containing Tenox 20° at 37°C from initial until the end of storage (Table 5).

Similar results were obtained from the Hunter lab color difference meter and Agtron- 500 unit. In Figs. 3 and 4 browning of the Tenox 20 and control samples for air-and nitrogen-packed at 37°C of Clone 709 is indicated by a notable decrease in the relative spectral reflections. The decrease in the values was much less in the samples stored at room temperature, indicating that the extent of browning is directly related to storage temperature. The browning in nitrogen-packed samples was virtually identical to those packed in air.

There was a very negligible difference in the relative spectral reflection values of the Russet Burbank samples (Table 7) comparing to Clone 709. This indicated that no

Table 3. Measurement of non-enzymatic browning of dehydrated mashed potatoes (Clone 709) during storage, air-packed, 21±2° and 37±1°C . by the Hunter lab color difference meter.

Time (wk)	Treat-ments	21±2°C			37±1°C		
		L	a_L	b_L	L	a_L	b_L
0	Control	79.83	-1.76	18.88	79.83	-1.76	18.88
	+ T 20	80.77	-2.50	19.04	80.77	-2.50	19.04
	+ T 26	81.67	-2.71	19.28	81.67	-2.71	19.28
2	Control	79.33	-1.70	18.73	77.03	-0.98	19.96
	+ T 20	80.30	-2.29	19.27	80.04	-1.75	19.25
	+ T 26	81.63	-2.92	19.12	81.19	-2.55	19.38
4	Control	79.13	-1.65	18.97	75.90	-0.40	20.25
	+ T 20	80.29	-2.10	19.00	79.41	-1.35	19.53
	+ T 26	81.87	-2.53	18.58	81.50	-2.17	18.70
5	Control	79.30	-1.41	18.86	75.60	+0.20	20.60
	+ T 20	80.05	-2.05	18.91	78.52	-1.10	19.96
	+ T 26	81.18	-2.74	18.71	80.10	-2.10	19.44
8	Control	78.73	-1.65	19.40	73.96	+0.50	21.50
	+ T 20	79.80	-2.20	19.44	77.42	-0.70	20.45
	+ T 26	81.32	-2.65	19.80	80.05	-1.95	19.80
10	Control	78.92	-1.25	19.05	73.70	+0.90	21.70
	+ T 20	80.03	-1.88	19.10	76.96	-0.15	20.95
	+ T 26	81.57	-2.54	18.52	79.60	-1.50	19.80
12	Control	78.50	-1.35	19.14	73.00	+0.95	22.18
	+ T 20	80.05	-2.20	19.05	76.78	-0.20	20.85
	+ T 26	81.35	-2.54	18.60	79.73	-1.60	19.93
14	Control	78.80	-1.30	18.90	72.53	+1.10	22.20
	+ T 20	80.15	-2.10	19.13	75.83	-0.10	21.20
	+ T 26	81.35	-2.70	19.30	79.15	-1.50	20.04
16	Control	78.29	-1.22	19.24	72.10	+1.40	22.64
	+ T 20	80.25	-2.10	19.10	75.30	+0.26	21.45
	+ T 26	80.95	-2.70	18.70	78.55	-1.25	20.30

Table 4. Measurement of non-enzymatic browning of dehydrated mashed potatoes (Clone 709) during storage, nitrogen-packed, 21±2° and 37±1° C by the Hunter lab color difference meter

Time (wk)	Treatments	21±2°C			37±1°C		
		L	a_L	b_L	L	a_L	b_L
0	Control	79.83	-1.76	18.88	79.83	-1.76	18.88
	+ T 20	80.77	-2.50	19.04	80.77	-2.50	19.04
	+ T 26	81.67	-2.71	19.28	81.67	-2.71	19.28
2	Control	79.15	-1.94	19.00	78.06	-1.14	19.08
	+ T 20	80.91	-2.18	19.17	79.26	-1.87	19.79
	+ T 26	81.58	-2.85	19.28	80.95	-2.60	19.46
6	Control	78.90	-1.62	19.12	75.98	-0.38	20.70
	+ T 20	79.75	-2.23	19.46	78.28	-1.44	20.30
	+ T 26	81.49	-2.80	19.30	80.48	-2.20	19.92
10	Control	78.19	-1.33	19.37	73.43	+0.55	21.54
	+ T 20	80.05	-2.15	19.42	75.80	-0.15	21.34
	+ T 26	81.38	-2.83	19.35	79.45	-1.90	20.50
14	Control	77.97	-0.90	19.50	71.70	+1.70	22.00
	+ T 20	80.00	-1.80	19.30	75.95	0.00	21.75
	+ T 26	80.98	-2.30	19.40	78.95	-1.50	20.95
18	Control	77.95	-0.90	19.70	71.70	+1.99	23.00
	+ T 20	79.88	-1.85	19.70	74.80	+0.50	22.00
	+ T 26	81.05	-2.40	19.35	78.10	-1.10	21.50

Table 5. Measurement of non-enzymatic browing of dehydrated mashed potatoes (Russet Burbank) during storage, air-packed, 21±2°and 37±1 °C by the Hunter lab color difference meter

Time (wk)	Treat-ments	21±2°C			37±1° C		
		L	a_L	b_L	L	a_L	b_L
0	Control	83.25	-3.01	14.23	83.25	-3.01	14.23
	+ T 20	83.75	-2.96	14.29	83.75	-2.96	14.29
	+ T 26	83.70	-3.11	14.64	83.70	-3.11	14.64
2	Control	83.53	-2.61	13.73	83.64	-2.41	13.51
	+ T 20	83.77	-2.50	13.83	83.19	-2.71	14.35
	+ T 26	83.80	-2.80	14.30	83.62	-2.46	13.93
4	Control	83.63	-2.38	13.58	83.25	-2.35	13.60
	+ T 20	83.68	-2.43	13.67	83.33	-2.16	14.10
	+ T 26	83.05	-2.76	14.17	83.22	-2.48	14.00
6	Control	83.58	-2.37	13.43	83.42	-2.24	13.90
	+ T 20	83.92	-2.40	13.72	83.20	-2.21	14.45
	+ T 26	84.00	-2.60	13.75	83.54	-2.22	13.89
8	Control	83.60	-2.47	13.12	83.02	-2.32	14.15
	+ T 20	83.89	-2.51	13.55	82.70	-2.25	14.70
	+ T 26	83.99	-2.60	13.56	83.40	-2.38	13.80
10	Control	83.08	-2.52	13.51	82.70	-2.56	14.48
	+ T 20	83.55	-2.68	13.95	81.93	-2.20	15.55
	+ T 26	83.78	-2.56	13.68	82.92	-2.43	14.07
12	Control	82.97	-2.45	13.40	82.50	-2.45	15.05
	+ T 20	83.13	-2.55	14.00	81.70	-2.00	15.70
	+ T 26	83.28	-2.60	13.93	82.67	-2.40	14.40
14	Control	83.00	-2.50	13.35	82.20	-2.20	14.95
	+ T 20	83.30	-2.60	14.00	81.55	-1.90	16.30
	+ T 26	83.70	-2.50	13.60	82.68	-2.20	14.00
16	Control	83.00	-2.20	13.10	83.00	-2.20	14.90
	+ T 20	83.30	-2.30	13.55	81.52	-1.55	16.55
	+ T 26	83.70	-2.20	13.45	83.20	-2.30	14.20

Table 6. Measurement of non-enzymatic browing of dehydrated mashed potatoes (Russet Burbank) during storage, nitrogen-packed , 21±2° and 37±1°C by the Hunter lab color difference meter

Time (wk)	Treatments	21±2°C			37±1°C		
		L	a_L	b_L	L	a_L	b_L
0	Control	83.25	-3.01	14.23	83.25	-3.01	14.23
	+ T 20	83.75	-2.96	14.29	83.75	-2.96	14.29
	+ T 26	83.70	-3.11	14.64	83.70	-3.11	14.64
2	Control	83.60	-2.84	14.00	84.00	-2.65	13.35
	+ T 20	83.30	-3.08	14.19	83.66	-2.76	14.04
	+ T 26	83.75	-3.00	14.47	83.92	-2.66	14.02
6	Control	83.50	-2.79	14.10	83.28	-2.54	14.50
	+ T 20	83.80	-2.97	14.10	83.18	-2.57	14.70
	+ T 26	83.70	-3.00	14.57	83.75	-2.75	14.45
10	Control	83.46	-2.87	13.95	82.64	-2.57	15.05
	+ T 20	83.30	-2.80	14.10	82.75	-2.60	15.18
	+ T 26	83.43	-3.00	14.42	83.03	-2.90	14.80
14	Control	83.35	-2.50	13.56	82.55	-2.50	15.44
	+ T 20	83.55	-2.80	14.00	82.20	-2.50	16.10
	+ T 26	83.35	-2.80	14.34	82.62	-2.80	15.30
18	Control	83.85	-2.20	13.15	82.70	-2.30	15.00
	+ T 20	83.85	-2.60	13.50	82.40	-2.30	16.35
	+ T 26	83.80	-2.60	14.00	82.90	-2.60	15.54

Table 7. Measurement of non-enzymatic browing of dehydrated mashed potatoes (Russet Burbank) during storage, air-or nitrogen-packed 21±2° and 37±1°C by Agtron 500.

Time (wk)	Treatments	Relative spectral reflections			
		21±2°C		37±1°C	
		Air-pack	Nitrogen-pack	Air-pack	Nitrogen-pack
0	Control	80.0	80.0	80.0	80.0
	+ T 20	79.5	79.5	79.5	79.5
	+ T 26	79.0	79.0	79.0	79.0
2	Control	77.0	80.0	76.0	79.0
	+ T 20	78.0	79.0	75.5	78.5
	+ T 26	79.0	80.0	78.5	78.5
4	Control	75.5	-	76.0	-
	+ T 20	78.0	-	76.0	-
	+ T 26	79.0	-	78.5	-
6	Control	75.5	80.0	76.5	76.5
	+ T 20	79.0	79.0	75.5	77.0
	+ T 26	78.0	79.0	77.0	80.0
8	Control	76.0	-	76.0	-
	+ T 20	79.5	-	75.0	-
	+ T 26	79.0	-	77.0	-
10	Control	77.0	80.0	75.0	76.5
	+ T 20	78.0	79.0	72.0	77.0
	+ T 26	76.0	79.0	76.5	78.0
12	Control	75.5	-	75.0	-
	+ T 20	77.0	-	70.0	-
	+ T 26	78.0	-	77.5	-
14	Control	76.0	77.0	73.5	75.5
	+ T 20	77.5	78.0	70.0	73.0
	+ T 26	78.0	79.0	76.0	76.0
16	Control	77.0	-	73.5	-
	+ T 20	78.0	-	67.0	-
	+ T 26	77.0	-	77.0	-
18	Control	-	77.5	-	73.0
	+ T 20	-	78.0	-	73.0
	+ T 26	-	78.5	-	76.0

color change occurred in Russet Burbank samples throughout the storage. There was, however, an unusual change of values in samples containing Tenox 20 and stored at 37°C. The instrument indicated that these samples were somewhat darker at the end of storage.

CONCLUSION

The higher temperature of the storage markedly increased the rate of lipid oxidation and non-enzymatic browning. This was clearly shown in Clone 709 samples. Tenox 26 stabilized the samples better than Tenox 20. The latter antioxidant stabilized both Clone 709 and Russet Burbank at room temperature, while Tenox 26 was effective at 21 and 37 Samples of Clone 709 containing Tenox 20 at 37°C also appeared to brown to a greater extent than samples containing Tenox 26.

There appeared to be little if any benefit to use antioxidants in nitrogen samples, since these samples showed an excellent shelf-life, especially at room temperature.

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