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Quality of dehydrated potato flakes in long-term storage

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ABSTRACT

There is interest in dehydrated potatoes packaged for long-term storage for uses such as military rations, disaster relief, and space travel. Research has shown the effects of processing and storage for up to 2 years on dehydrated potatoes, including such aspects as sensory properties and nutrient degradation. The quality of dehydrated potatoes during long-term storage has not been studied. The objective of this study was to examine the quality of dehydrated potato flakes held at ambient conditions in residential storage for up to 30 years.

Thirteen samples of dehydrated potato flakes packaged in No. 10 cans were obtained from donors. Sample age ranged from <1 to 30 years. A 50-member consumer panel rated the samples for appearance, aroma, texture, flavor, and overall acceptability on a 9-point hedonic scale. Acceptance was defined as the percentage of panelists willing to use the product in everyday and emergency situations. Additional analyses included can seam integrity, headspace oxygen, water activity, color, and headspace hexanal.

Hedonic scores ranged from 3.74 to 6.57 and declined significantly over time. Acceptance for everyday use was significantly lower than acceptance for emergency use, and both declined significantly over time. Water activity ranged from 0.27 to 0.39, hexanal concentration ranged from 0 to 0.0209 µg/g, and headspace oxygen ranged from 0.59 to 19%. Can seams varied in quality, but were adequate to maintain a hermetic seal. There was no significant correlation between headspace hexanal of dry flakes and hedonic scores of reconstituted product.

Sensory data indicate that potato flakes held in residential storage had greater than 50% acceptance for daily use at 5 years, and greater than 50% acceptance for emergency use at 30 years of storage. Dehydrated potato flakes appear to retain sufficient quality over time to warrant consideration for long-term storage purposes.

INTRODUCTION

Potatoes are conveniently stored for future use as dehydrated mashed potato flakes. Due to their nutrient content and light weight, potato flakes have been considered for applications such as military combat rations, extended space travel, humanitarian food shipments, and disaster relief. These applications require that foods be acceptable for consumption and provide adequate nutrition after long periods of storage.

The United States Department of Defense specifies that foods used in combat rations must be acceptable for at least three years of storage at 80°F (Mermelstein 2001, US Army 2004). NASA requires that foods deployed on extended space exploration missions have a shelf-life of three to five years (NASA 2003). Food supplies designated for humanitarian relief must be able to tolerate extended storage and extreme conditions. Failure to maintain quality and acceptability under these conditions renders a food unfit for these purposes. To be a suitable option for these rigorous applications, dehydrated potatoes must be reasonably stable over long periods of storage under conditions that may be less than ideal.

Numerous studies have been conducted on dehydrated potatoes stored for up to two years (Baardseth 1989, Sapers 1975, Lisberg and Chen 1973, Sapers and others 1972, Boggs and others 1964). However, there is little data in the literature concerning quality after storage for longer periods. More research is required to determine the effects of long-term storage on such parameters as lipid oxidation, vitamin degradation, and sensory acceptability of potato flakes. A better understanding of the effects of storage on potatoes will facilitate determination of the storage period over which the product maintains sufficient acceptability to be used as a staple food source. The purpose of this study was to evaluate the effects of storage on the sensory properties and stability of dehydrated potato flakes held in hermetically sealed containers and maintained at ambient temperatures for up to 30 years.

METHODOLOGY

Samples

Thirteen samples of dehydrated mashed potato flakes were collected from donors throughout the United States. All cans represented one retail brand, with the exception of the two cans comprising Sample Number 9. All samples were originally packaged in No. 10 cans and held in residential storage at ambient temperatures (approximately 13 to 27°C). Sampling excluded cans known to be heat abused or otherwise damaged. Sample age ranged from <1 to 30 years. The two cans of Sample Number 9 contained oxygen absorbers. All other samples were packaged with ambient oxygen.

Headspace Oxygen, Can Seams, Water Activity, and Color

Headspace oxygen was measured using a 3500-Series Headspace Oxygen Analyzer (Illinois Instruments, Inc., Johnsburg, IL). Can seams were evaluated using the SeamMate System (Onevision Corporation, Westerville, OH) to measure the following seam properties: thickness, width, body hook, cover hook, and overlap. Seam tightness was rated on a scale of 0-100%. The seams were given an overall rating of good, satisfactory, or poor by an experienced evaluator. Water activity was measured using an Aqualab CX-2 (Decagon Devices, Inc., Pullman, WA). Color was quantified on the Hunter L*, a*, b* scale using a HunterLab ColorFlex colorimeter (Hunter Associates Laboratory, Inc., Reston, VA).

Sensory Analysis

Sensory analysis was conducted at the BYU Sensory Laboratory using standard procedures. Samples were prepared according to package directions and served in a randomized manner to a 50-member consumer panel in 4 visits. Panelists evaluated aroma, flavor, texture and overall acceptability using a 9-point hedonic scale. Panelists were also asked if they would use the products in everyday and/or emergency situations.

Vitamin C

Vitamin C analysis followed the method of Wang (2000) using an Agilent Model 1100 high performance liquid chromatograph (Agilent Technologies, Palo Alto, CA) equipped with a Zorbax SB-Aq C18 reverse phase column (Phenomenex, Inc., Torrence, CA) and a diode array detector. Quantification was performed using an external standard. Sample preparation and extraction were carried out under subdued light.

Hexanal

Hexanal was determined following AOCS Recommended Practice Cg 4-94 and the method of Fritsch and Gale (1977), using a Perkin Elmer HS-40XL headspace autosampler (Perkin Elmer, Norwalk, CT) coupled to a Hewlett Packard 5890 Series II Plus gas chromatograph (Hewlett Packard, Palo Alto, CA). Sample vials were thermostatted at 60°C for 40 minutes, and then pressurized to 25 psi for 3 minutes prior to withdrawal of headspace sample and injection into the column. The chromatograph was equipped with a dimethylpolysiloxane DB-1 column (Agilent Technologies, Palo Alto, CA). Detection was carried out with a flame ionization detector. Results were obtained by comparing hexanal peaks against 4-heptanone as an internal standard.

Data Analysis

Data was analyzed for significance using Statistical Analysis System software (SAS Institute, 1999). A mixed model analysis of variance (PROC MIXED) was used for the sensory data. PROC GLM was used for the water activity and vitamin data. Both models used Duncan's multiple range test to determine significant differences between means. Significant differences were defined as $p<0.05$.

Figure 1: Headspace oxygen in cans of potato flakes stored long-term.

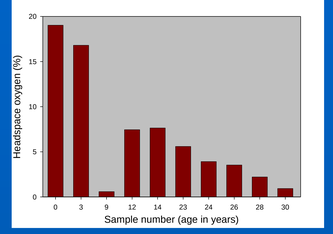

Figure 2: Water activity of unreconstituted flakes stored in hermetically sealed cans

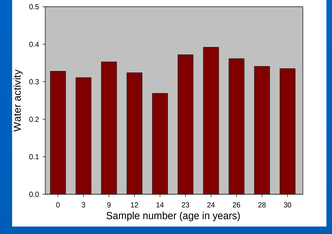

Table 1: Mean hedonic scores of reconstituted potato flakes stored long-term

Sample # (age in years)	0	3	9	12	14	23	24	26	28	30
Appearance	6.97^{a}	7.13^{a}	7.19^{a}	6.78^{a}	6.97^{a}	6.99^{a}	5.70^{c}	6.06^{b}	5.73^{c}	4.09^{e}
Aroma	5.95^{c}	5.95^{a}	5.94^{c}	5.31^{bc}	5.38^{cd}	5.35^{cd}	4.53^{fg}	4.87^{def}	4.89^{def}	3.97^{g}
Flavor	6.34^{ab}	6.19^{abc}	6.51^{a}	5.86^{bc}	5.69^{cd}	5.66^{cde}	5.02^{f}	5.15^{def}	5.14^{ef}	3.66^{g}
Texture	6.45^{ab}	6.90^{a}	6.37^{abc}	6.48^{ab}	6.36^{abc}	6.44^{abc}	5.92^{c}	6.21^{bc}	6.32^{bc}	5.23^{d}
Overall	6.46^{b}	6.57^{a}	6.47^{a}	6.03^{ab}	5.81^{bc}	6.00^{ab}	5.27^{c}	5.39^{c}	5.24^{c}	3.74^{d}

Common superscripts in the same row indicate no significant difference ($p>0.05$)

Figure 3: Acceptance for everyday use of reconstituted flakes plotted versus sample age (dashed line is 95% prediction interval)

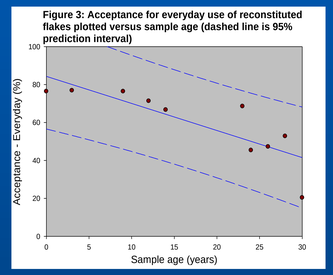

Figure 4: Acceptance for emergency use of reconstituted flakes plotted versus sample age (dashed line is 95% prediction interval)

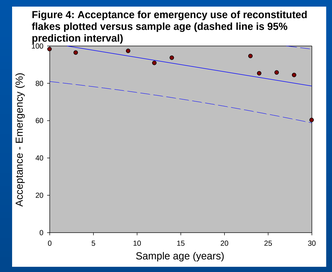

Figure 5: Hunter L* values of potato flakes

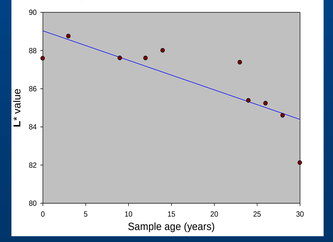

Figure 6: Hunter L* values of potato flakes versus overall acceptabilityof reconstituted flakes

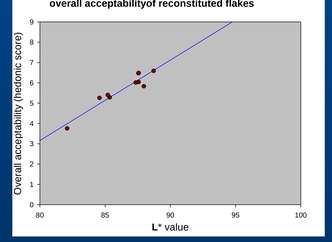

Figure 7: Headspace hexanal in potato flakes during long-term storage (ND = none detected)

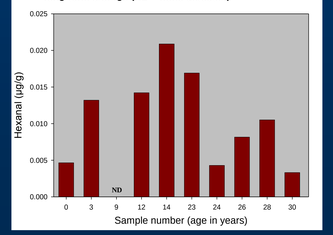

Table 2: Vitamin C content of dry potato flakes

Sample # (age in years)	Vitamin C (µg/g)
0	109
3	98
9	96
12	102
14	100
23	119
24	100
26	98
28	101
30	92

RESULTS AND DISCUSSION

Headspace Oxygen, Can Seams, and Water Activity

Can seams varied in quality, but all cans had seams that were sufficient to maintain a hermetic seal**.** Headspace oxygen exhibited extreme variation, ranging from 0.59 to 19% (Figure 1). The apparent decrease in headspace oxygen over time may be related to lipid oxidation and/or hydrocarbon contamination of the oxygen sensor. Nissen and others (2002) found increasing levels of the hydrocarbons ethane and pentane over time during storage of potato flakes. Sample water activities were relatively consistent, ranging from 0.27 to 0.39 (Figure 2). This corresponds to a moisture content of 6 to 7%, which is consistent with published values (Baardseth 1989, Iglesias and Chirife 1982, Sapers and others 1972).

Sensory

As shown in Table 1, ranges for hedonic score means were: 4.09-7.19 for appearance, 3.97-5.95 for aroma, 3.66-6.51 for flavor, 5.23-6.90 for texture, and 3.74-6.57 for overall. Scores in each category declined significantly with increasing sample age. Acceptance for everyday use ranged from 20.4 to 76.9% (Figure 3), and acceptance for emergency use ranged from 60.2 to 98.2% (Figure 4). For both everyday and emergency use, percent acceptance declined significantly with increasing sample age.

Color

Hunter **a*** values ranged from -0.810 to 2.240. Hunter **b*** values ranged from 15.96 to 28.74. Both **a*** and **b***values increased significantly with sample age (data for **a*** and **b*** are not shown). Hunter **L*** values ranged from 82.11 to 88.74, and decreased significantly with sample age (Figure 5). These results indicate that the older samples were significantly darker than the newer samples. Low **L*** values were highly correlated (r^2=0.903) with lower overall hedonic scores (Figure 6) as well as appearance (r^2=0.947, data not shown). This indicates that browning during storage is associated with diminished appearance and overall acceptability scores.

Headspace Hexanal

Hexanal values ranged from 0 to 0.02 µg/g and did not significantly increase with increasing sample age (p=0.917, Figure 7). Sample Number 9 was the only sample that contained oxygen absorbers, and it also had the lowest levels of both oxygen (Figure 1) and headspace hexanal (Figure 7). This suggests that oxygen absorbers could reduce lipid oxidation during storage. Also, hexanal levels may not be well correlated with sample age due to the breakdown of hexanal into other oxidation products over time (Kalsec 2004). Hexanal values were not well correlated with flavor scores (r^2=0.024) nor overall hedonic scores (r^2=0.052). This is likely due to evaporation of volatile compounds during cooking. Thus, hexanal and other oxidation products do not necessarily diminish the sensory acceptability of the product, since they appear to be driven off before consumption.

Vitamin C

Vitamin C content of samples ranged from 92 to 119 µg/g (Table 2). Vitamin C content did not significantly decrease with increasing sample age (p=0.705), nor was Vitamin C well correlated with hexanal values (r^2=0.165). This indicates that the Vitamin C content did not decrease over time and that the presence of volatile lipid oxidation products is not a good indicator of Vitamin C status. It appears that Vitamin C is fairly stable over long-term storage of dehydrated mashed potato flakes.

CONCLUSIONS

Hedonic scores for dehydrated mashed potato flakes held in residential storage at ambient temperatures declined significantly over time**.** Browning during storage appeared to contribute to lower overall acceptability scores. The presence of lipid oxidation products in the dry product was not related to flavor scores of the reconstituted flakes. Vitamin C levels appeared to remain fairly constant during extended storage. Sensory data suggest that dehydrated mashed potato flakes held in residential storage at ambient temperatures had greater than 50% acceptance for everyday use at 5 years, and greater than 50% acceptance for emergency use at 30 years. Dehydrated potato flakes appear to retain sufficient quality over time to warrant consideration for long-term storage purposes.

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