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Effects of long-term storage on wheat flour packaged in a low oxygen atmosphere

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ABSTRACT

There is interest in the long-term storage of food for applications such as space flight, military rations, and disaster relief. Long-term storage of wheat flour under modified atmospheres has not been extensively studied. The objective of this research was to examine the effects of long-term storage on wheat flour packaged in a low oxygen atmosphere.

Ten samples of wheat flour packaged in No. 10 cans were obtained from donors. Samples ranged in age from 0.5-11 years and were stored at ambient temperatures (13-27ºC). Oxygen levels were below 1%, and moisture contents were between 12.0% and 14.3%. Color was assessed using a HunterLab colorimeter. Free fatty acids were quantified using a copper-soap assay with oleic acid as the standard. Headspace hexanal was measured using GC-FID. A 50-member sensory panel evaluated flour for odor and appearance, and bread for aroma, appearance, texture, flavor, and overall acceptance, using a 9-point hedonic scale. Panelists also indicated whether they would use the product in everyday and emergency situations.

Sensory results indicated that age was not correlated with any of the sensory parameters for both flour and bread; flour maintained >90% acceptance, and bread maintained >88% acceptance, for use in emergency situations. L* values ranged from 92.21-93.40, and were correlated with mean hedonic scores for flour appearance and everyday acceptance. Free fatty acids ranged from 6.16-22.1 µmol/g flour, and hexanal ranged from 0.030-0.21 µg/g flour. Free fatty acids were correlated with flour age.

Consumers disliked browning of flour, but the browning was not perceived after making the flour into bread. Free fatty acids were the best predictors of flour age. Acceptance data indicated that storing wheat flour in a reduced oxygen environment was a viable option for long-term storage.

INTRODUCTION

There is interest in the long-term storage of food for applications such as space flight, military rations, and disaster relief. Wheat flour is a major component of the American diet and is therefore important to include in food storage settings. The changes that occur in flour during storage have been reviewed (Wang and Flores 1999; Pomeranz 1988). Lipids are the most labile components of wheat flour and their degradation causes a decrease in sensory acceptability and functional properties.

The changes that occur in wheat flour stored in a low oxygen environment have not been well documented. The purpose of the present study was to determine the degree of lipid degradation, sensory acceptability, and functional properties of flour stored in a low oxygen environment for up to 11 years.

METHODOLOGY

SAMPLES

Ten samples of wheat flour packaged in No. 10 cans were obtained from donors. Headspace oxygen was <1% as measured by a 3500-Series Headspace Oxygen Analyzer (Illinois Instruments, Inc., Johnsburg, IL). Samples ranged in age from 0.5-11 years and were stored at ambient temperatures (13-27ºC). Moisture was determined by heating the sample in a force draft oven at 130°C for one hour. Flour moisture contents were between 12.0% and 14.3% (data not shown).

SENSORY ANALYSIS

Two sensory panels consisting of 50 panelists were conducted at the BYU Sensory Laboratory using standard procedures. The first panel was designed to determine the acceptability of the flour. Subjects were served 10 g of flour in a 2-oz. capped serving cup in a randomized manner, and instructed to remove the cap and quickly smell the flour. Panelists evaluated aroma and appearance using a 9-point hedonic scale and reported whether they would use it for baking in emergency and everyday situations.

The second panel was conducted to determine the acceptability of bread made from the flour. Panelists were served half a slice of bread made from each flour sample and were asked to evaluate aroma, texture, flavor, and overall acceptability, using a 9-point hedonic scale. Acceptance for everyday and emergency use was assessed by asking panelists if they would consume the product under those conditions. Because of insufficient product, only one 0.5 year-old sample was available.

COLOR

Color was quantified on each flour sample using a HunterLab ColorFlex spectrophotometer (Hunter Associates Laboratory, Inc. Reston, VA). Results were expressed using the CIE L*, a*, b* scale. The L* scale is from 0 to 100, where 0 is completely black and 100 is completely white.

BREAD-MAKING AND LOAF VOLUME

Bread was made from the stored flour samples by combining 1200 g flour, 63.6 g yeast, 72 g sucrose, 18 g NaCl, 36 g shortening, and 780 ml water in an electric mixer. Dough was mixed for 10 minutes and divided into four equal portions and allowed to rise for 1 hour. Dough was then shaped into loaves and placed into 20x10 cm bread pans and proofed for 22 minutes, followed by baking for 22 minutes at 215°C. After cooling for one hour, loaf volume was determined by rapeseed displacement.

FREE FATTY ACIDS

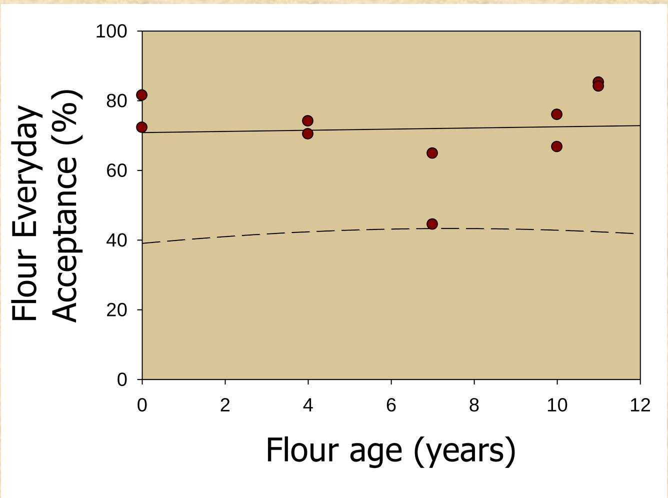
Lipids were extracted from 1 g of flour using three 10 ml hexane extractions of 20 min each, with shanking. Hexane was then removed over a hot water bath and extracted lipids were redissolved in isooctane. Free fatty acids were then quantified spectrophotometrically by a copper-soap assay (Kwon and Rhee 1986). Oleic acid was used as the standard.

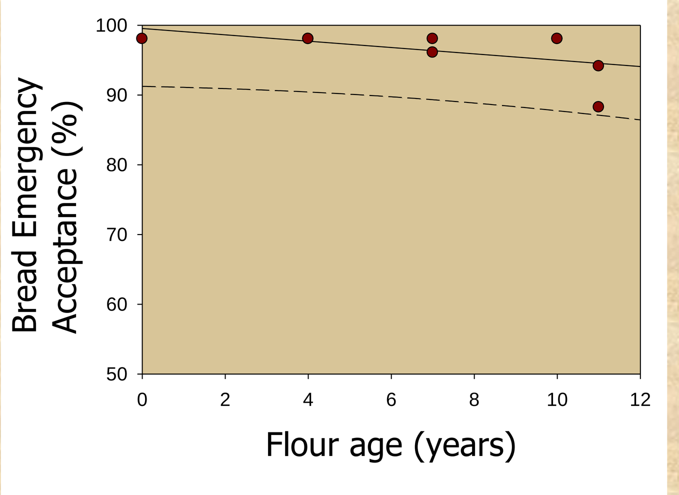
HEXANAL

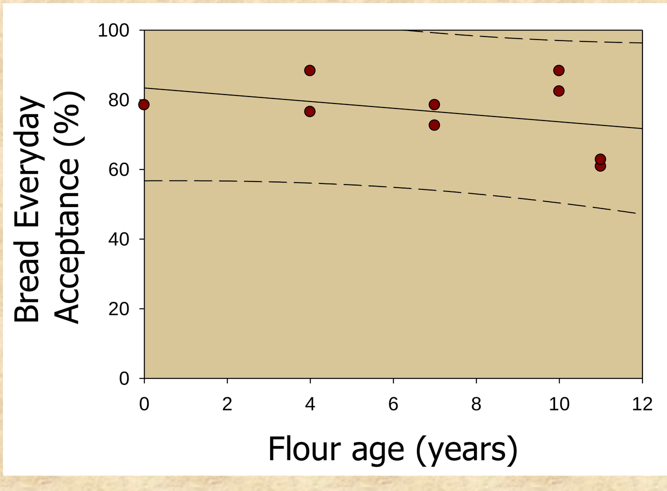
Headspace hexanal was determined using a Perkin-Elmer HS-40XL headspace autosampler (Perkin Elmer, Norwalk, CT) coupled to a Hewlett Packard 5890 Series II Plus gas chromatograph. Samples were equilibrated at 60°C for 40 minutes, and then pressurized to 25 psi before headspace sampling and injection onto the column. A dimethylpolysiloxane DB-1 column was used, and detection was carried out with a flame ionization detector. Hexanal was quantified by comparing the hexanal peak with that of 4-heptanone, an internal standard.

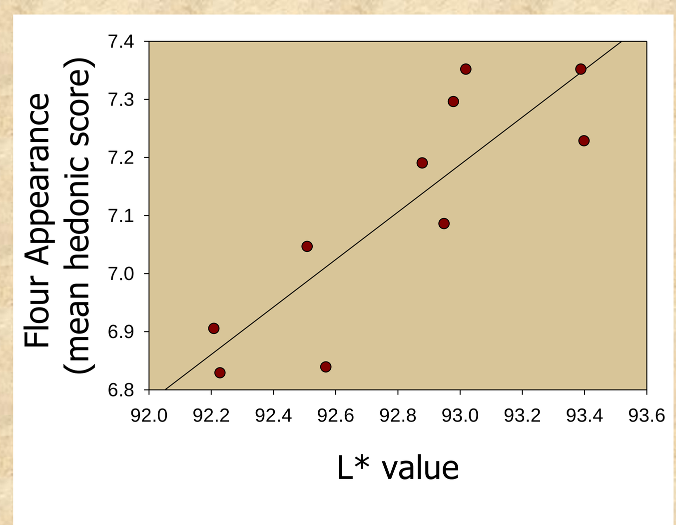
DATA ANALYSIS

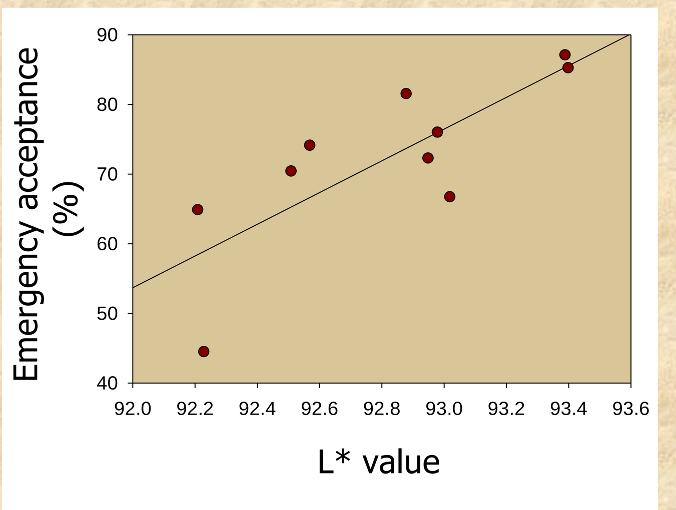
Data was analyzed for significance using Statistical Analysis System software (SAS Institute, 1999). A mixed model analysis of variance (PROC MIXES) with Duncan's Multiple Range Test was used for the sensory data. Correlation was assessed using regression analysis (PROC REG). Significant differences were defined as p<0.05.

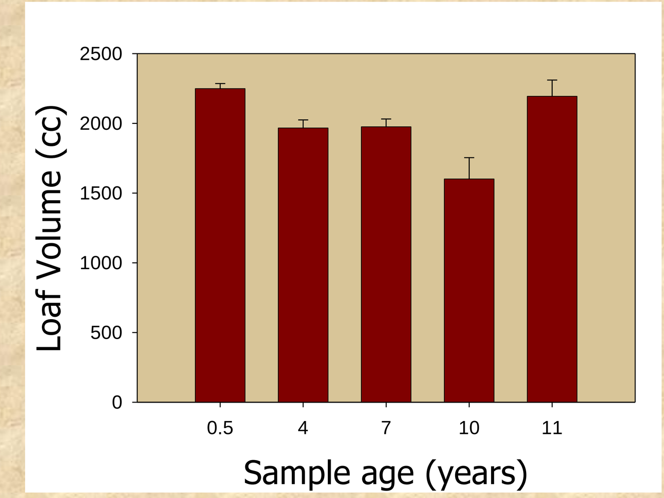


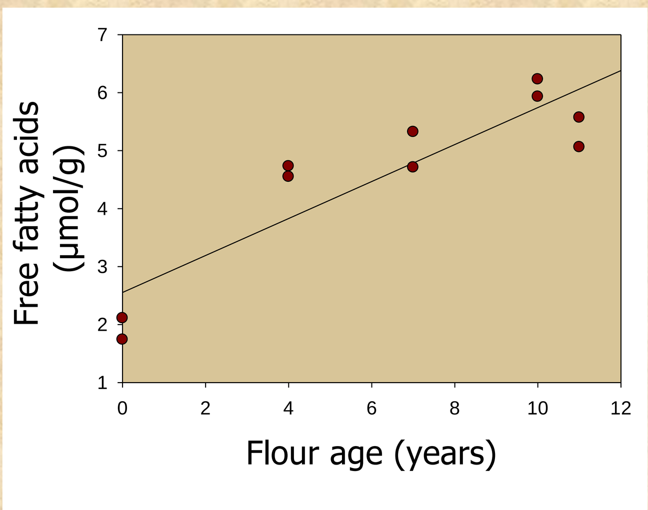


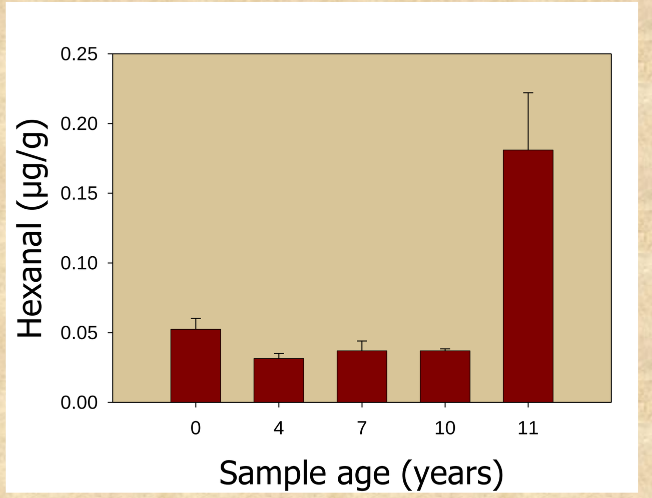












RESULTS AND DISCUSSION

SENSORY ANALYSIS

Mean hedonic scores for aroma and appearance of flour are shown in **Table 1**. Aroma scores ranged from 5.08 to 6.87, and appearance scores ranged from 6.83-7.35. Flour age was not correlated with aroma or appearance. All flour maintained >90% acceptance for use in emergency situations (**Figure 1**), indicating that people would use the flour for baking in emergency situations. For everyday use, one flour sample (7 years) fell below 50% acceptance (**Figure 2**).

Mean hedonic scores for aroma, appearance, texture, flavor, and overall acceptability of bread are shown in **Table 2**. Scores for overall acceptability ranged from 6.67 to 7.71. Although there were significant differences between samples, none of the parameters correlated with flour age. Acceptance of the bread in emergency situations showed >88% acceptance over the storage period of 11 years (**Figure 3**). All bread samples were >60% acceptance for everyday use (**Figure 4**).

COLOR

L* values ranged from 92.21 to 93.40 (data not shown). L* was correlated with flour appearance (**Figure 3**) and emergency acceptance (**Figure 4**), but was not correlated with any of the sensory results from the bread panel. This suggests that consumers dislike browning of flour, but that the browning is not perceived after making the flour into bread.

LOAF VOLUME

Loaf volume ranged from 1480 to 2250 cc (**Figure 5**). Loaf volume was not correlated with flour age, suggesting that loaf volume was not impaired by age.

FREE FATTY ACIDS

Free fatty acids ranged from 6.16 to 22.1 µmol/g (data not shown). **Figure 6** illustrates the relationship between flour age and free fatty acids, showing more extensive lipid hydrolysis with increasing flour age.

HEXANAL

As shown in **Figure 7**, all the flour samples ranged from 0.029 to 0.058 µg hexanal/g, except the two 11 year-old samples, which were much higher (0.21 and 0.15 µg/g). Because of the non-uniformity of these data, correlation statistics could not be determined. After removing the two outliers, there were still no significant correlations of flour headspace hexanal with any of the sensory parameters.

CONCLUSIONS

Consumers disliked browning of flour, but the browning was not perceived after making the flour into bread. Free fatty acids were the best predictor of flour age. Acceptance data indicated that storing wheat flour in a reduced oxygen environment was a viable option for long-term storage.

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