# Beer Oxidation as Measured by Spectrophotometric and Thiobarbituric Acid Techniques

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## Abstract

The color and clarity of beer as well as its 2-thiobarbituric acid reactive substances are three important beer oxidation indices. In this study, beer absorbance at 430, 515 and 600nm as well as the increase in thiobarbituric reactive substances (TBARS) was monitored in commercially bottled ale and lager during storage over 0-15 weeks at 2-30°C. The change in absorbencies and TBARS levels followed pseudo-first order kinetics. Arrhenius behaviour was also observed. Not surprisingly, increasing temperatures intensified these oxidation reactions. Rate constants for color change were generally greater for lager than ale, but the rate of haze formation was greater for ale. High correlations between the absorbencies and TBARS values (0.871 to 0.991) were observed. This study demonstrates that the non-linear kinetic models can be applied to beer oxidation data to predict their change with time.

## Introduction

Since the advent of packaged beer, brewers have been concerned with its oxidative stability. While numerous methods have been reported the spectrophotometric measurement of beer as well as the thiobarbituric acid test [1] remain as simple yet valid means of measuring beer oxidation. In this study we examined changes of beer absorbance and TBARS by use of a first-order model [2]:

$$B_t = B_e - (B_e - B_o)e^{(-kt)} \qquad (1)$$

where B is the absorbance (*of a product*) at time t, 0 and at equilibrium (e), and k is the reaction rate.

## Methods

Fresh pale ale (5% v/v alcohol) and lager pilsner style (4% v/v alcohol) beers were sampled from a local brewery and stored at 2, 20 and 30°C for up to 102 d. Absorbencies at 430, 515 and 600 nm were measured. The TBA method III of Grigsby and Palamand[1] involves extraction of degassed beer into chloroform. The extract is then evaporated, TBA reagent added and TBA reactive substances measured at 445 nm after heating at 60°C for one hour.

Equation 1 was fit to all the absorbance data with the non-linear regression module of Systat (Ver 11, San Jose, CA).

## Results

All of the absorbance measurements were dependent on time could be well modelled by equation 1. Table I and Figures 1 and 2 depict the best fit results for the 430 nm and TBA reactive substances. These reactions were temperature dependent and their rates could be fit by the Arrhenius equation (not shown here). In general the TBARS values exhibited less variability and were more suitable predictors of beer oxidation. High correlations were also observed between the measurements as shown in Figure 3.

**Table I.** Estimates for reaction rate, & initial & equilibrium values for browning (@430nm) and TBARS (@445nm) for commercially bottled beer as determined by the fit of equation 1.

| Beer | Assay | T ( C) | k (d)$^{-1}$ | A.S.E | $A_o$ | A.S.E. | $A_e$ | A.S.E. | $r^2$ |
|---|---|---|---|---|---|---|---|---|---|
| Lager | A430 | 2 | 0.067 | 0.017 | 0.096 | 0.004 | 0.150 | 0.003 | 0.862 |
| Lager | A430 | 20 | 0.072 | 0.018 | 0.096 | 0.005 | 0.158 | 0.004 | 0.854 |
| Lager | A430 | 30 | 0.074 | 0.024 | 0.094 | 0.008 | 0.175 | 0.008 | 0.833 |
| Ale | A430 | 2 | 0.051 | 0.013 | 0.165 | 0.003 | 0.211 | 0.003 | 0.872 |
| Ale | A430 | 20 | 0.057 | 0.011 | 0.160 | 0.006 | 0.269 | 0.006 | 0.921 |
| Ale | A430 | 30 | 0.066 | 0.017 | 0.156 | 0.011 | 0.303 | 0.010 | 0.881 |
| Lager | TBARS | 2 | 0.040 | 0.002 | 0.413 | 0.021 | 1.657 | 0.025 | 0.992 |
| Lager | TBARS | 20 | 0.050 | 0.003 | 0.489 | 0.025 | 1.732 | 0.024 | 0.990 |
| Lager | TBARS | 30 | 0.056 | 0.006 | 0.472 | 0.037 | 1.890 | 0.050 | 0.984 |
| Ale | TBARS | 2 | 0.046 | 0.002 | 0.619 | 0.015 | 1.799 | 0.017 | 0.995 |
| Ale | TBARS | 20 | 0.053 | 0.004 | 0.669 | 0.035 | 2.060 | 0.032 | 0.984 |
| Ale | TBARS | 30 | 0.057 | 0.005 | 0.642 | 0.038 | 2.341 | 0.054 | 0.988 |

Note n=18 or 21 data-points, A.S.E. - Asymptotic Standard Error

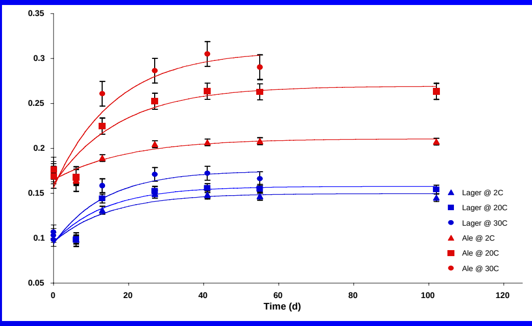


**Figure 1.** Absorbance at 430 nm for *Ale and Lager at 2, 20 and 30 °C Lines indicate best fit of Eq. 1.*

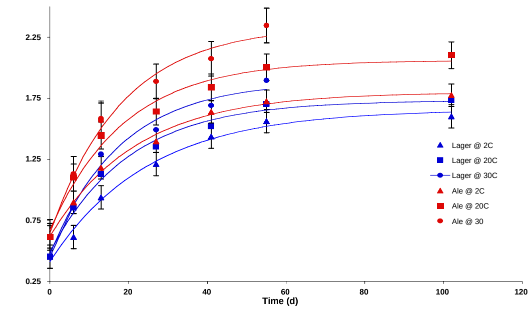


**Figure 2.** TBAR substances for *Ale and Lager at 2, 20 and 30 °C. Lines indicate best fit of Eq. 1.*

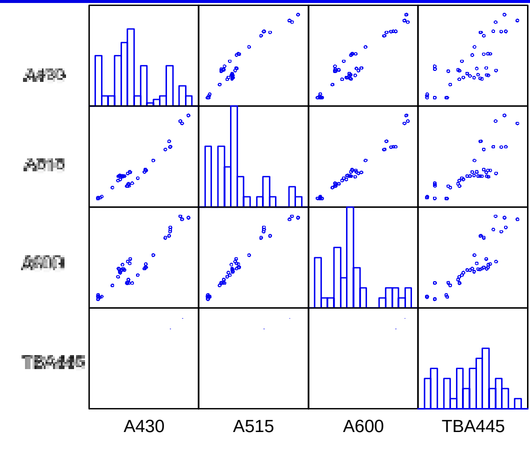


**Figure 3.** Correlation of absorbance and TBARS values.

## Conclusions

- Beer oxidation indices could be modelled by a pseudo-first order model (Eq. 1).
- As expected, reactions were temperature dependent.
- While high correlations existed between all the oxidation indicators, the TBA technique of Grigsby and Palamand was the most suitable assay (of those tested) to measure beer oxidation.

## References

1. Grigsby, J.H. and Palamand, S.R. Studies on the Staling of beer: the use of 2-thiobarbituric acid in the measurement of beer oxidation. *ASBC J.* 1975, **34 (2),** 49-55.
2. Speers, R.A.1976. The Effect of Copper, Iron and EDTA on Beer Oxidation. B.Sc. (Agr.) Thesis, Dept. of Food Science, Univ. British Columbia, Vancouver, BC.

## Acknowledgements

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