

SIMPLIFIED CORRELATION BETWEEN OTR DATA AND FOOD SHELF LIFE

Use oxygen transmission rate (OTR) results to theoretically estimate shelf life based on a few assumptions.

Summary

The study of a food shelf life requires special sensory and other food science lab tests, as well as packaging barrier studies such as an oxygen transmission rate (OTR) test.

With the OTR results and a few assumptions, food shelf life can be theoretically estimated to serve as reference for packaging design.

Assumptions

To establish a simple direct correlation between OTR and food shelf life, a few assumptions should be made for calculations.

For example:

- End of shelf life reason: Oxidation only
- Known packed food quantity: 30 g or 0.030 kg
- Maximum oxygen tolerance: 75 mg/kg of this product
The value of maximum oxygen tolerance is different for each food product, and should be decided by food scientists via sensory studies
- Package surface area: 437 cm² (or 0.0437 m²)
The permeable surface area of 437 cm² is from a 2-side pouch with approximate dimension of 6" x 6" (or 15cm x 15cm) minus areas used for seals.
- Permeation is the only factor for oxygen ingress

The product consumes ingressed O₂ immediately so that no O₂ accumulates inside the package. Therefore, the permeation driving force is constant.



Packaged food on store shelves.

EXAMPLES OF CALCULATION TO RELATE OTR AND SHELF LIFE

Examples

1. From known film OTR to estimate the shelf life of the food:

$$\text{Allowed } O_2 \text{ volume the product can take} = \\ 0.03 \text{ kg} \times 75 \text{ mg/kg} = 2.25 \text{ mg (or 1.58 cc at STP)}$$

Assume we tested a barrier film material with MOCON® OX-TRAN® 2/22 (Fig 2.) and obtained OTR of 2.0 cc/(m² · day) at 23°C with 100% O₂. For a package with 0.0437 m² permeable surface area, the OTR of the package at 20.9% O₂ will be:

$$\text{OTR (package)} = 2.0 \text{ cc}/(\text{m}^2 \cdot \text{day}) \times 0.0437 \text{ m}^2 \times 20.9\% = \\ 0.0183 \text{ cc}/(\text{package} \cdot \text{day})$$

Estimated shelf life for this product is:

$$1.58 \text{ cc} \div 0.0183 = 86 \text{ days}$$

2. From desired shelf life (6 months) to find proper film OTR level:

$$\text{Allowed } O_2 \text{ volume the product can take} = \\ 0.03 \text{ kg} \times 75 \text{ mg/kg} = 2.25 \text{ mg (or 1.58 cc at STP)}$$

Assume a desired shelf life: 6 months (182 days)

$$\text{Allowed OTR (package)} = \\ 1.58 \text{ cc} \div 182 \text{ days} = 0.0087 \text{ cc}/(\text{package} \cdot \text{day})$$

$$\text{Required film OTR with 20.9\% } O_2: 0.0087 \text{ cc}/(\text{pkg} \cdot \text{day}) \div \\ 0.0437 \text{ m}^2 = 0.2 \text{ cc}/(\text{m}^2 \cdot \text{day})$$

$$\text{Or with 100\% } O_2: 0.2 \text{ cc}/(\text{m}^2 \cdot \text{day}) \div 0.209 = 0.96 \text{ cc}/(\text{m}^2 \cdot \text{day})$$

Here, OTR of 0.96 c/(m² · day) is the starting point for required O₂ barrier film.

3. From tested OTR of a whole package to estimate shelf life

Using MOCON OX-TRAN 2/40 (Fig 2.) to obtain the OTR of a whole package at 23°C and 20.9% O₂:

$$\text{Tested OTR (package)} = 0.0085 \text{ cc}/(\text{package} \cdot \text{day})$$

Use the same allowed O₂ volume from above examples:
1.58 cc

Estimated shelf life for this product is:

$$1.58 \text{ cc} \div 0.0085 = 186 \text{ days}$$

NOTE: The above calculations used a very important value: maximum oxygen tolerance for the product. For different food products, this value is different and should be decided by food scientists via sensory studies.



Figure 1. OX-TRAN 2/22



Figure 2. OX-TRAN 2/40

Conclusion

- Permeation testing for film and package is important to ensure product shelf life.
- Correlation of OTR and food shelf life could be established if oxidation is the only cause to end of shelf life.
- Collaboration with food scientist to decide maximum oxygen tolerance value via research or sensory study to the specific food product.
- The estimated shelf life is a good reference for packaging R&D.