Effect of Packaging on Oil Product Quality

D.A. LEO, W.L. Clayton Research Center, 3333 North Central Expressway, Richardson, TX 75080

ABSTRACT

To maximize shelf life, entrained and headspace oxygen are to be minimized. Light exposure must also be kept to a minimum. Knowledge of the required residence time in the market and cost information on package alternatives must be available and assessed. Escalating prices for metal cans and for energy to produce glass continue to drive up the price of the containers. Fuel costs to transport the finished product continue to escalate. The trend toward light-weight plastic bottles will increase. Information on the expected performance of alternative plastic materials becomes more important. We must continue to seek out those materials which maximize protection while minimizing container costs. A final decision can be made when the critical factors are known. The ultimate decision to accept a particular package is dependent upon product protection, cost, convention and convenience. Our goal is acceptance by the consumer.

INTRODUCTION

Relatively few packaging studies have been published which deal with the effect of the package system on oil quality. These are in sharp contrast with the number of studies on the processing, handling and chemistry of fats and oils.

The type of package has a dramatic effect on shelf life of the finished oil. An oil which has been carefully processed to maximize palatability may be damaged by improper selection of the container. The objective is to maintain this optimum level of product quality for the longest period of time. Obviously, the length of residence time in the container, the cost of the container, the level and type of preservative added, if any, and the atmosphere within the container all affect the final decision in the selection of the package for the best price/value relationship.

QUALITY FACTORS

An understanding of the chemistry and processing of edible oils is critical to the supply of quality product to the world population. Packaging of this food must be considered as carefully as the processing if acceptable quality is to be maintained. The challenge then, is to understand the manner in which the package can affect the quality of fats and oils and the directions and steps necessary to maintain that quality until used by the consumer.

Many factors affect the quality of fats and oils during and after processing. This discussion will be limited to environmental factors since the container can only influence the accessibility of light, oxygen, heat and moisture to the product.

Light is an initiator and cause of reactions which ultimately result in deterioration of fats and oils. Sensitizers such as chlorophyll may play a role in promoting photooxidation. The source of light can be either artificial, of incandescent or fluorescent origin, or natural sunlight. The regions of interest within the light spectrum are the ultraviolet (UV) with wavelengths up to 390 nm and the visible region of violet and blue in the wavelengths of 390-490 nm.

The reaction of the fatty acid moiety of a triglyceride is of the general type in which the fatty acid forms a free radical having been initiated by light quanta through hydrogen atom or electron abstraction. This can proceed in the absence of molecular oxygen.

Oxygen may access the oil in several ways. Atmospheric oxygen may be entrained in the oil. Oxygen can also be available in the headspace of the container and by permeation of the walls of the container. Oxygen is the most critical of the factors affecting quality. It causes the formation of hydroperoxides, the components normally associated with rancid oil. A suggested oxidation mechanism for the hydroperoxide formation begins with the reaction of the free radical of the fatty acid moiety with singlet oxygen to form the peroxide radical which reacts readily with unsaturated sites to form the hydroperoxide and a free radical, thereby perpetuating the chain. The generally accepted progression of these reactions is initiation, propagation and termination. This is depicted (Fig. 1) by the reaction of linoleic acid in the presence of oxygen to form the free radical. These reactions increase in rate and intensity in the presence of light, heat and prooxidants such as chlorophyll and heavy metals.

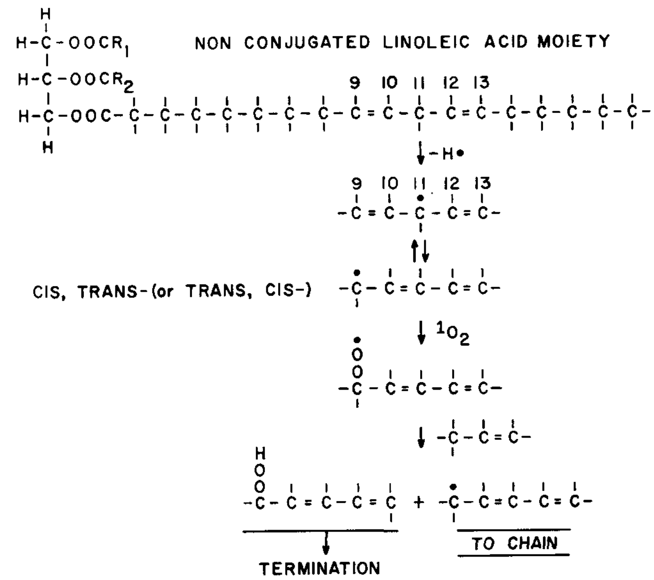

FIG. 1. Chain reaction for hydroperoxide formation.

Although heat can affect the stability of oils, the package can afford only minor protection in the form of insulation. Commercial packages do not differ significantly in the protection of the contents from heat. To provide insulating qualities to a consumer package which would result in any meaningful protection would be cumbersome, expensive and of questionable value.

Hydrolysis is the reaction of water on the triglyceride resulting in the formation of free fatty acids. Normally, this is an important consideration during the use of oils in cooking applications such as deep frying. Glass or tin will prevent incursion of moisture vapor. Plastic packaging materials, on the other hand, do allow varying amounts of moisture to pass through the walls. Theoretically, this moisture can result in hydrolysis. Practically, moisture ingress at the levels experienced in commerce has little effect, if any, on the rate of hydrolysis of fats and oils.

The package then, must effectively block light and the ingress of oxygen. The graph (Fig. 2) shows the percent transmittance of light through a typical wall thickness of 2 mm. As shown, amber glass affords significantly greater protection from the light in the UV and near UV ranges than does flint (clear) glass. The corrugated shipping case in which the primary containers are packed provides total opacity and light protection for the period of time in which the shipper is used. Continuing with those factors which affect quality (Table I), we see that metal affords maximum protection against the oxygen and light. Other common packaging materials for oils protect the contents to a lesser degree.

The relative cost of packages of comparable capacity is given. Flint glass is chosen as the standard and given a unit of one. Cost is an important input variable in the selection of the container material. Shelf life is another consideration in the final selection (see Table II). Every oil type such as soybean, corn or sunflower must be tested in all materials under consideration to determine suitability and shelf life.

Stability can be enhanced by proper selection of packing method. Oil which has been deaerated prior to filling into a package which has been sparged with an inert gas such as nitrogen will have improved shelf life over similar oil which has been processed and packed under atmospheric conditions.

ACKNOWLEDGMENTS

Visual aids were developed, in part, from information and materials provided by the Soltex Polymer Corporation and Owens-Illinois, Glass Container Division. Technical assistance was provided by R.R. Allen, S.S. Lin and B.E. Welsh.

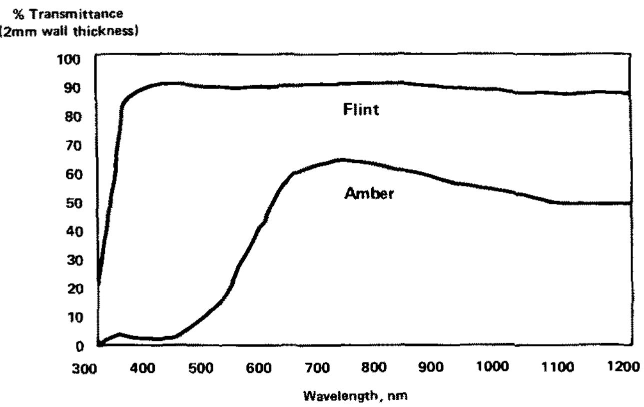

FIG. 2. Transmittance of light through amber and flint glass.

TABLE II

Relative Stability of Like Oils under Similar Packing Conditions

Package material	Stability (months)
Metal	24+
Glass, amber	ca. 18
Glass, flint	12-16
PVC	9-12
HDPE	3-6

Interpreted from various data sources.

TABLE I

Package Material Effectiveness—Level of Incursion

Material	O_2[a]	H_2O[b]	Light[c] UV	Light[c] Visible	Relative economics (USA)
Metal	0	0		0	1.4
Glass, amber	0	0	3%	3-65%	1
Glass, flint	0	0		90%	1
Nitrile copolymer (acrylonitrile/methylacrylate)	0.8	5		ca. 90%	1.2
PET, oriented (polyethylene terephthalate)	10	4		ca. 90%	1
PVC (polyvinyl chloride)	16	2.5		ca. 90%	1
HDPE (high density polyethylene)	110	0.5	31-44%	57%	0.8-0.9

[a]Oxygen transmission rate = cm^3/mil/100 $in.^2$/atmosphere/24 hr at 73 F, 50 % RH.
[b]Water vapor transmission rate = GM/mil/100 $in.^2$/atmosphere/24 hr at 100 F, 90% RH.
[c]Light transmission is percentage of light passing through typical wall thickness.