Food Packaging and Shelf Life 8 (2016) 9–13

Contents lists available at ScienceDirect

Food Packaging and Shelf Life

journal homepage: http://www.elsevier.com/locate/fpsl

The effects of transportation hazards on shelf life of packaged potato chips

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ARTICLE INFO

Article history:
Received 23 January 2015
Received in revised form 28 January 2016
Accepted 24 February 2016
Available online 9 March 2016

Keywords:
Transportation hazards
Shelf life
Potato chips

ABSTRACT

Kettle cooked potato chips packaged inside metallized oriented polypropylene bags were used to evaluate the effects of simulated transportation on shelf life. While shelf life testing provides accurate results for shelf dating, the research project assessed whether or not subjecting packaged products to known transportation hazards can increase or accelerate the deteriorative factors that affect the shelf life of a produce. By stressing the packages through laboratory simulated transportation hazards, it created failures to the packages that would not have normally shown up during a traditional test protocol, such as accelerated shelf life testing (ASLT). Results showed packages evaluated through a simulated transport test reported an average oxygen transmission rate three times greater than samples having not been transport tested. Outcomes from this study showed the rate at which some properties of the food and package can increase as a result of the simulated transportation, versus standard ASLT with only increased temperature and humidity. Differences of significance were observed between the simulated transportation and the standard ASLT samples when comparing headspace composition, moisture content, and TBA testing ($P < 0.05$).

1. Introduction

Potato chips have become America's favorite snack, with U.S. retail sales over $6 billion a year (Clark, 2003). Product development has led to the introduction of various styles and flavors of the potato chip, each with their own unique twist on an age old classic. Kettle cooked potato chips are promoted as a healthier alternative to the fried potato chip. The cooking process of kettle chips is done at low temperatures, and the natural flavor of potatoes are maintained due to minimum usage of artificial or excess ingredients in the preparation process (Classic Foods, 2012).

Regardless of potato chip type it is imperative to understand the intrinsic and extrinsic properties of the food in order to provide the consumer with the highest quality product. Foods that are moisture sensitive, like potato chips, are vulnerable to change in the environment and if left unpackaged will first become stale. The package serves as a barrier to providing resistance to the diffusion of gases, water vapor, and off-aromas. Furthermore, package atmosphere can be modified to retard deteriorative reactions and increase the expected shelf life of a product.

The shelf life can be defined as the period of time from the production and packaging of a product to the point at which the product first becomes unacceptable under defined environmental conditions (Lee, Yam, & Piergiovanni, 2008). Depending on the food products nature, various properties or quality indices must be experimentally followed as a function of time in order to evaluate degradation of food product quality through the use of shelf life tests. However, real time shelf life tests for shelf stable food products are time-consuming. In an effort to speed up this process and to fully account for all the degradation criteria, accelerated shelf life testing (ASLT) methods have been adopted (Charlotte, Wadso, & Sjoholm, 2005).

Factors influencing the shelf life of a product are the initial quality and inherent nature of the product, processing methods, barrier properties of the packaging, and the transportation and storage conditions (temperature and relative humidity) (Zweep, 2011). Although the conditions of transportation and warehousing are included, missing from these factors are the other hazards occurring throughout the supply chain. Throughout the supply chain packaged products are subjected to additional hazards; shock, vibration, and compression, which all can lead to adverse effects on the packages integrity (Brandenburg & Lee, 2001; Goodwin & Young, 2011). Packaged products traveling through the supply chain will be handled, dropped, vibrated, and compressed

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http://dx.doi.org/10.1016/j.fpsl.2016.02.003
2214-2894/

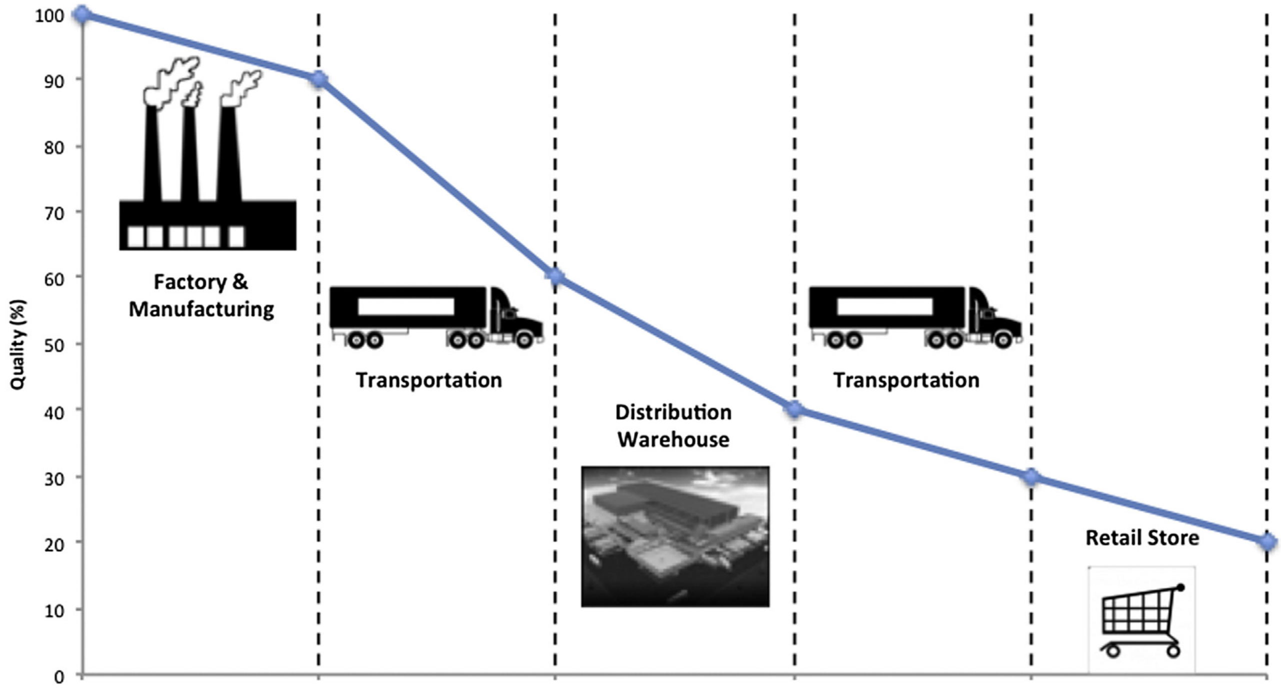

Fig. 1. Notional food deterioration during the process of distribution (Richardson, 2008).

multiple times until they reach the consumer. Fig. 1 displays the food deterioration as a function of product distribution. As a result, packages can breakdown and lose their integrity, which can increase deterioration factors of the food and ultimately adversely affect the product's predicted shelf life. Ways in which the integrity of a package can be lost during the storage and distribution are due to the presence of defects in the seal area or package body as a result of abusive handling (Keller et al., 2003).

The basic assumption underlying ASLT is that the principles of chemical kinetics can be applied to quantify the effects that extrinsic factors such as temperature, humidity, gas atmosphere, and light have on the rate of deteriorative reactions (Robertson, 2006). ASLT typically involves the use of increased temperature to accelerate the deteriorative reactions, but does not subject the package or the food product to any other distribution hazards, such as shock, vibration, or compression, which packages will encounter during the movement of goods. Therefore, a portion of this research will be evaluating whether the deteriorative rates of certain aspects of the food will be increased as a result of the mechanical and manual abuse the packages will be put through during distribution to the consumer.

The goals of this research are as follows: (1) evaluate packaged products being subjected to simulated distribution hazards (2) determine if there is a difference in product performance for packaged products only accelerated by temperature as compared to packaged products undergoing simulated distribution hazards as part of the ASLT.

2. Materials and methods

2.1. Packaged product

The packaged product selected for this research was 1.5 oz bags of kettle cooked potato chips. Packaged products were obtained from three separate production runs. The ingredients used for the product were potatoes, canola oil, and salt. The 3.0 mil film used for this application was constructed of the following: matte oriented polypropylene (OPP)/low-density polyethylene (LDPE)-ethylene vinyl alcohol copolymer (EVOH)-low-density polyethylene (LDPE)/ metalized oriented polypropylene (Met-OPP). The film had OTR and MVTR values of 0.18 g/($m^2 \times$ day) and 0.15 g/($m^2 \times$ day) respectively. Prior to sealing the packages were flushed with nitrogen.

2.2. Headspace analysis

Headspace composition for each sample was determined using a MOCON® PAC CHECK® Model 650 dual headspace gas analyzer for modified atmosphere packages (MOCON Inc., Minneapolis, MN). For each variable, three packages were randomly selected and used for this test. The needle of the analyzer was inserted through the neoprene plastic pad into the package through which a sample of gas was extracted and analyzed. Headspace gas was sampled directly after packaging and then every 7 days thereafter.

2.3. Thiobarbituric acid (TBA) test

For each variable, three packages were randomly selected and 1.0 g of test product was added to 20 ml of 10% trichloroacetic acid (TCA) in a beaker and stirred for 20 min. Samples were split equally into two 15 ml falcon tubes and centrifuged for 20 min at 2500 rpm. 2 ml of filtrate from each falcon tube was removed and mixed with 2 ml of 0.3% thiobarbituric acid (TBA) in falcon tubes. Falcon tubes were placed in a boiled water bath and held for 20 min. Tubes were removed and allowed to cool. Tubes were centrifuged for 20 min at 2500 rpm. The absorbance was measured at 531 nm using a Genesys 10S UV–vis Spectrophotometer (Thermo Fisher Scientific, Madison, WI). The value was expressed in terms of optical density (OD).

2.4. Moisture content

The moisture content of each sample was measured using a Mettler-Toledo HR73Halogen Moisture Analyzer (Mettler-Toledo GmbH, Laboratory and Weighing Technologies, Greifensee, Switzerland). 2.0 g of product was selected from the packaged