Innovations in Produce Packaging Technology

by H. Louis Cooperhouse

The tremendous growth in the fresh-cut produce industry over the past 15 years would not have occurred if it were not for advances in packaging technology. The development of the branded cut lettuce category, in particular, acted as the catalyst that helped to launch the entire fresh-cut industry and ushered in the new generation of convenience foods that are available throughout the food industry today. Cut lettuce products will continue to account for a significant portion of category sales volume for the near term, but their success has opened the door for new opportunities in other packaged fruit and vegetable products. The convenience of product use, and the variety offered in prepackaged items, has changed consumer purchasing behavior and created "halo" effects for other prepackaged products.

Evolution of the Produce Aisle

The produce aisle will continue to transition from a commodity to a branded orientation over the decade ahead. Packaging technology will play a central role in how these brands are displayed and communicated to the public. In addition, packaging technology will serve as an integral part of the product's overall HACCP program and will be key in providing maximum attainable levels of product safety, quality and shelf life.

In the years ahead, the fresh-cut category is projected to evolve considerably because of continual advances and applications of packaging technology. New fresh-cut fruit offerings are now available, such as pre-cut melons in party trays with a 10-14 day shelf life and pre-sliced apples with a 3-6 week shelf life. Innovations in packaging technologies have created new marketing opportunities as well, such as component products that allow the user to combine fresh and processed ingredients for a "freshly-prepared" or "freshly-assembled" salad product. Such products are now being offered to foodservice operators and retail customers, in which fresh and/or processed ingredients, dressings and/or seasonings are separately packaged and combined at store, on the go, or at home. These freshly prepared component kits provide products not previously available, such as Chicken Caesar Salad or a Chef Salad.

Packaging Hurdles

The packaging stage of manufacturing offers a number of highly differentiated options for the food processor. These packaging hurdles include modified atmosphere packaging (MAP), clean room packaging, packaging materials, active packaging systems and intelligent packaging systems. Used alone or in a combination, these technologies can be employed to improve product quality and/or safety. Application of these technologies, and the incorporation of a complete HACCP system, will enable the marketability of a wide array of new product offerings for consumers in the years ahead.

Modified Atmosphere Packaging

MAP is used regularly today as a hurdle for value-added produce, but differs dramatically in its application based on whether the product being packaged is still respiring or if it has been inactivated by cooking, blanching or other such processes. In the MAP process, product is packaged in an atmosphere that is different from that of air. Air normally contains 78.08 percent nitrogen, 20.96 percent oxygen and 0.03 percent carbon dioxide.

Frequently, MAP is a two-stage process. It begins when a vacuum is first pulled on the product so that as much oxygen as possible can be removed from the system. This is then followed by a "back flush" of nitrogen and/or carbon dioxide and/or other gases. Nitrogen is used as a sterile filler gas to dilute the concentration of carbon dioxide and oxygen in the package. Carbon dioxide has bacteriostatic and fungistatic properties, but at too high a level the formation of carbonic acid can give the product an acid taste over time; package collapse may also occur.

Variations of the MAP process exist, including controlled atmosphere packaging (CAP), vacuum packaging (VP) and vacuum skin packaging (VSP). CAP is an active system that continuously maintains the desired atmosphere within a package throughout the shelf life of a product. VP is a form of MAP in that it reduces the amount of air contained in a package yet doesn't replace the diluted air with a predetermined mixture of a new gas. VSP uses a highly flexible plastic film that molds itself to the contours of the food being packaged.

MAP via reduced-oxygen may be a technology chosen to help a fresh-cut processor achieve a much longer shelf life. However, because MAP results in a dramatic change in the *time* it takes for product to spoil, and the *type* of bacteria that will cause this spoilage, it creates significant additional risk as well. Conditions can be created in which an anaerobic pathogen such as *C. botulinum* can grow, produce toxin and cause food-borne disease. This is due to a number of factors such as extremely low oxygen levels, prolonged shelf life and potential for temperature abuse. However, incorporation of other barriers and microbiological challenge studies will minimize such risks.

Packaging Materials

Packaging materials may contain enhanced barriers to oxygen, moisture and/or light and may have anti-fog capabilities to reduce condensation. Laminated materials are widely used in the industry today. They are manufactured by bonding two or more layers together with adhesives in which each layer performs a particular role. Microperforation is a technology that can be used with high-respiring fresh-cut produce. It offers high moisture vapor transmission rates for products like cauliflower.

Produce commodities are often classified by their respiratory requirements. Potatoes, radishes and tomatoes are generally considered low respirers, while asparagus, broccoli and mushrooms are considered heavy respirers. Once commodities are cut and handled, product deterioration accelerates. As the respiration rate is increased, the tissue becomes more susceptible to oxidative discoloration and microbial growth is enhanced. By reducing a product's respiration rate, senescence (the ripening process) can be delayed. Packaging plays a unique role by matching the respiration rate of the product with the transmission rate of the packaging material. By definition, the transmission rate is the rate at which a gas like oxygen or carbon dioxide passes through a given material. It is critical to match the oxygen transmission rate (OTR) of the packaging material with the respiration rate of the product.

New innovations are on the frontier in which antimicrobial agents are being incorporated into films. Agents that have been tested and which have shown efficacy include: carbon dioxide, sulfur dioxide, grapefruit seed extract, nisin, lysozyme (an enzyme found in eggs) and allyl isothiocyanate (a component found in horseradish oil). Challenges exist with respect to optimizing the release of the antimicrobial agent, while ensuring minimal flavor migration and maintaining desired gas permeation rates.

Clean Room Packaging

A "clean room" is an area in which a statistically defined level of particulates (like dust, bacteria, molds, etc.) is permitted in the air. The level is measured as the number of particles per cubic foot of air according to a federal standard. In the food industry, it is typically most relevant to install a clean room within the packaging area of the plant as a way to minimize post-processing contamination. Positive air pressure in the packaging area and HEPA (High Efficiency Particulate Air) filters over 99.97 percent effective for particles one micron or less, will create a clean-room atmosphere. Makeup air is one of the central issues in maintaining clean airflow in the processing plant. The highest positive, filtered air pressure should be where the product is last in touch with the environment, normally the packaging area. Air should flow from processing/packaging to raw material preparation to raw material receipt in one direction and should be positive to the outside.

The effects of a clean room can be quickly compromised by the actions of employees in the same area. Other mitigating factors include the movement of materials in and out of the clean room and the manner of air distribution. Clean room procedures, and the entrenched training regarding "high risk" and "low risk" locations and practices, are very common in European refrigerated food factories and serve as outstanding models for refrigerated foods manufacturing and employee training.

Active Packaging Systems

Many advances in active packaging have occurred in recent years and many more are forthcoming. Active packaging technologies involve an interaction between the packaging used and the food and may include a visible or invisible packaging additive that extends the food's shelf life and quality.

Oxygen scavenger systems work in concert with the MAP process to reduce the residual oxygen level to minimal levels. New oxygen-absorbing films are now available, are "invisible" to the consumer and can increase the shelf life of products by 50 percent. The film remains dormant until it is activated on the packaging line by ultraviolet lights that trigger the scavenging reaction through a patented activation process. Many consumers find stand-alone sachets with "do not eat" and other necessary language, or a sachet affixed as a pressure-sensitive label to the inside of "lidding" material, as unsightly and will find this invisible solution much more to their liking.

Many other forms of active packaging systems exist. Desiccants and other moisture control systems adsorb water vapor from the air or are in the form of pads that absorb moisture as it drips from the product. Carbon dioxide generating or scavenging systems also exist and are appropriate when the maintenance of a high carbon dioxide level is desired.

Intelligent packaging systems

Intelligent packaging systems are sensors that provide information about the product to the consumer, foodservice operator or other user. The most widely known intelligent packaging system is the time temperature indicator. Various types of commercialized indicators have been used as a visual tool that correlates with the acceptable quality, or lack thereof, of perishable foods. These indicators track the relationship between time and temperature and their impact on spoilage or some other end-point of product acceptability.

New types of indicators are being developed that signal product quality directly rather than depend on a consumer's inference of quality from temperature history. Next-generation freshness indicators are able to potentially detect specific foreign materials in packaged products, such as bacteria, pesticides and proteins resulting from genetic modification. Although this technology has not yet been marketed, grocers and their customers may ultimately be able to determine if a specific pathogenic bacterium is present in a packaged food.

Other systems under development use an enhanced bar code format to screen products susceptible to spoilage from the time they are packaged until the time they are removed for preparation. Bar code readers at any station in processing or in retail markets will be able to automatically reject any product that reflects a positive reading for potential or actual contamination. This system embodies well-established immunochemical techniques, but provides an innovative delivery system. A membrane impregnated with antibodies with specificity to selected pathogenic organisms becomes an integral part of the bar code itself, making the bar code no longer readable if a particular organism is present.

Just like time temperature indicators, these innovations in intelligent packaging will need to demonstrate that their activation correlates with actual temperature abuse or pathogenic contamination. Nevertheless, these are promising signs of the types of innovations that will result in an improvement in the safety of our food system. ■

Editor's Note: *Lou Cooperhouse is director of the Food Innovation Research & Extension Center of Cook College and the New Jersey Agricultural Experiment Station at Rutgers University. He has also recently published a comprehensive study entitle, "Retail Prepared Refrigerated Foods: The Market and Technologies." For further information, contact Cooperhouse at (732) 537-1901 or at cooperhouse@aesop.rutgers.edu.*

Letter to the Editor

Cooperhouse Column on Target with Food Safety Issues

Dear Fresh Cut,

I have noticed frequent articles from Mr. Lou Cooperhouse, president and CEO of Food Spectrum, and a contributing columnist of your magazine to be very much "on target" to the industry. His column, *Innovations in Food Safety,* is an excellent overview of what I feel all fresh-cut processors should know. I have taken several of the recent copies to processors I work with. My customers feel that continued information on food safety and the manner in which Mr. Cooperhouse presents this is among the best in the industry.

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