Innovations in Sustainable Food Packaging

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February, 2010

Introduction

It can be difficult to believe that in a time when consumers are tightening their belts and manufactures are cutting costs, consumers still care about sustainability. After all, who really cares about going green, when they don't have any left in their wallets? However, a June 2009 *The Consumer Network Inc.* web based survey polled more than 2000 Americans. Of that 2000, 25% were willing to pay more money for less packaging, 26% of men were willing to pay for Eco-Friendly Packaging and an astounding 35% of men and 45% of women were willing to pay more for reusable packaging. [1] For the first time, reusable packaging has taken priority over packaging "Made in America". Could it be that in the depths of a recession consumers are finally beginning to waste less, protect the environment, and become more *sustainable*?

Sustainability is word often used and rarely defined. According to the Bruntland Commission on Environment and Development in 1987, sustainability is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [2] Needless to say, this blanket definition is open to interpretation. Frequently, sustainable packaging definitions are complex, misunderstood and so technical that it's nearly impossible for anyone package to comply. However despite the confusion, there are three standards that all sustainable packages share: environmental, social, and financial. This trio is referred to as the "Triple Bottom Line" and it represents the balance between profitability and responsibility that all sustainable packaging needs to be successful.

All across the world companies are looking for new ways to reduce costs while still providing new innovative packaging. This innovation is driven entirely by an unprecedented consumer demand for environmental awareness. [1] The right packaging has never been more important. Riding the crest of this new wave is a variety of ingenious products and methods adopted by companies' as well as a

multiplicity of experimental materials yet to be fully developed. This research paper will give an overview of the people, products, materials and machinery behind the sustainable food packaging movement.

Recent History of Sustainable Food Packaging Innovation

Though thrust into the spotlight by Al Gore's documentary an *Inconvenient Truth*, sustainability is not a new idea. Companies' moving to more sustainable means of packaging can be traced back to the earlier 1970's. Often viewed as public enemy number one, and the root of American obesity, McDonald's is actually one of the forerunners for environmentally friendly packaging. In the early 1970's, after being the subject controversy regarding excessive logging, McDonald's founder Ray Kroc spent millions contracting the Stanford Research Institute (SRI) to perform an environmental impact study.[3] The study compared the (at the time) current non-recyclable paperboard packaging with the recently developed polystyrene (PS) clam shells and cups. PS was found to be recyclable, easier to manufacture, and considerably less polluting than its rival. PS was quickly adopted as the company's main form of packaging. "If there is a better package…we'll use it!" [3] and McDonald's (Perseco packaging) stayed true to this promise when in 1991, due to growing concerns in Chlorinated Fluorocarbons (CFC) from the production of PS, they switched to Poly-Wrap Coated Wax. Then in 1993 to a corrugated micro-flute weighing 40% less, made with post-consumer fiber, cornstarch adhesive, and even soy-based ink.

Large corporations were not the only ones interested in going green: on a local note, Jamba Juice, a San Luis Obispo founded company; performed extensive research in the early 1990's to find the most sustainable cup for their smoothies. The two candidates at the time were paper and Polystyrene. The research showed that paper cups use six times more raw material, 36 times more electricity to manufacture, two times the cooling water, 58 times the waste water, 33 times more chemicals, and

three times the air pollution that PS requires. [4] Ironically, 15 years after their research began, Jamba juice is still under scrutiny for their use of “styrofoam” in areas of California such as Berkley and Santa Cruz.

Arguably, no company has done more in recent history to influence sustainable food packaging than Starbucks. Starbucks spent four years collaborating with its supply chain partners to develop the first cup made from 10% post consumer fibers to be allowed in direct contact with food. In 2006 Starbucks obtained a letter of “Non-objection” from the FDA and after another year of testing the project was approved. Post consumer fiber cups were issued to Starbucks locations world wide, and the door was open for the food packaging community to follow suit and produce their own recycled products. With the adoption of the 10% post consumer cup, Starbucks estimates a savings of 11 tons (78 trees), 580 million BTU’s of heat, 47 million gallons of waste water, and 3 million pounds of solid waste each year. [3]

Down Gauging Bottles

Down Gauging is simply using less source material to manufacture the walls of a package. Having a thick, hefty water PET bottle was once accepted as an emotional sense of luxury amongst manufactures and consumers. However in the eve of ever changing climate, with 100 million tons of plastic produced and 10 million tons of plastic ending up in the ocean annually,[6] experts agree that there is simply no more room for both luxury and responsibility in the plastic bottle industry. Though it may not be as flashy as “biodegradability” down gauging is a guaranteed way to reduce source material, save the manufactures money and stem the accretion of plastics in landfills and waterways across the planet. Both Pepsi and Coca Cola, two laggards to the down grading movement, are finally starting to adopt thinner lighter bottles for their respective products Aquafina and Dasani. Coca Cola’s Dasani bottle is now 30% lighter weighing in at 12.8 grams. Pepsi has produced a new bottle weighing a mere

10.9 grams bearing the appropriate title of “Eco-fina”. This a staggering reduction from the 24 gram behemoth sold in 2002.[5] Nestle, not to be outdone by its soda slinging rivals, has announced the use of their new “Eco-shape” water bottle. The bottle will come in three sizes, use 30% less poly ethylene terepthalate (PET) than its competitors, and be available for Arrowhead, Deer Park, Ice Mountain, Ozarka, Poland Spring and Zephyrhills. [6]

Sleeker Packages

The methodology behind down gauging is being embraced not only in bottling but throughout the entire packaging community. The big question asked is, “How can we cut material use but still offer the same quality, convenience and value expected by our customers?” Kraft, A global leader in this innovation, “shed 150 million pounds of packaging material since 2005”according to a February, 2010 Food and Beverage Packaging article [7] Kraft attributes their success to the “Kraft Packaging Eco-Calculator” a tool that allows packages to be designed for optimum efficiency early on in the creation phase. The calculator has allowed for Kraft to reduce Oscar Mayer Deli Creations paperboard packaging by 30%. This design will reduce an estimated 1.2 million pounds of paperboard waste annually. In Australia Kraft redesigned their salad dressing and cut an annual 100,000 pounds of plastic. In the U.K. Kraft has designed a refillable plastic coffee container to reduce packaging 97% by weight. [7]

Following Kraft’s lead, Hormel Foods, has pulled the paperboard sleeve from their “Lloyds Heat-and-Eat barbecue meat line.” Paired with in-mold labeling and a user-friendly Poly Propylene (PP) tub from Airlite Plastics, Hormel estimates annual savings of 1,000 tons of paperboard per year. The tub features recessed sides to be advertised upright on shelves as well as tabs to be safely removed from the microwave. [8]

Meanwhile, a strange occurrence has been documented in the cereal industry. For the first time, Kellogg's and General Mills brands are under pressure from a "bottom shelf" competitor. While claiming only 10 of the 50 major national cereal brands, Malt-o-Meal has been able to take advantage of the recent popularity of sustainability. In 2008 Malt-o-Meal began printing on all of their Poly ethylene (PE) bags of cereal "75% less packaging"[9] than their Kellogg's or General Mills rival. The new marketing tactic, combined with a sealable top, and a Terra Cycle recycling campaign has left its much larger competitors scrambling to shed source material and redesign their cereals' image. In response Kellogg's has reported developing a new shorter, wider carton using 8% less paperboard and still holding the same volume of product.

Shortening Skirts

Often ignored due to their complexity, lack of material, and tight regulations, closures and skirting are providing more opportunities to shed source material from packaging. Both Kraft and Nestle have started reducing closure skirt length to further lighten their near optimal bottles. Switching from a 485 to a 400 style closure and eliminating a mere .085 inches per skirt will reduce molding energy, cut shipping costs, and most importantly prevent millions of tons of plastic from entering landfills and waterways each year. Skeptics argue that in reducing the length of skirting, the security of the product can become jeopardized because there are fewer threads in contact with the bottle. However Craig Sawicki, executive vice president with TricorBraun states that adjustments made to the sealing characteristics of the cap can be used to "make up for that difference in thread engagement." [10]

Thinner Films

Though only ten thousands of an inch thick, shrink wrap is no longer immune from the industry outbreak of down gauging. AEP industries have cut thickness by 21% transitioning from 80 gauge to 63 and 47 gauge Linear Low Density Polyethylene (LLDPE). Michael Hildreth, Product manager at AEP believes that "sustainability is both an economic and ecological model" [11] reports savings upwards of 15% for the end user while simultaneously preventing tons of wasted LLDPE. Hildreth explains that 63 gauge for automated wrapping and 47 gauge for manual wrapping is the lowest possible thickness LLDPE stretch wrap can be and still maintain its necessary properties.

In addition to being thinner, shrink-wrap is now being stretched further. While 200% pre-stretch percentage was common a few years ago, shrink-wrap is now approaching a 300% pre-stretch percentage, meaning that a one foot section of shrink-wrap can now be stretched upwards of 3 feet. This enhanced stretchiness combined with Wulftec's more accurate film positioning system and can save 60 miles of shrink-wrap per year. [11]

Machines behind Down Gauging

Machines that were once able to inconsequentially brutalize the packaging of the 90's are now being confronted with a new challenge. An optimum thickness, often hastily designed, "Eco" package, cannot stand the same abuse of its hardwearing predecessor. As a result machines are now being tasked to process and handle these delicate packages with an unprecedented standard of precision gentleness. PET bottles in particular are feeling the bulge brought on by minimal containment says Chuck Wepler, VP and general manager of Quadrel Labeling Systems, who exclaims that PET bottles now have the characteristics of a "football" with compound curves instead of flat sides. [12] This creates a unique challenge in that labeling must now act as load bearing girdle to suck in the curves of PET bottles.

This requires extra force on behalf of the labeling squeegee, and if not properly applied, may tear the label or rupture the bottle.

With the increased risk of package failure, a new standard of cleanliness must also be maintained during processing. Conveyors and weigh checkers that were once never required to be sanitized are often in direct contact with food products. This spillage requires the assembly line be shut down and manually cleaned before processing can continue. Adjusting machinery to handle the new "less is more" packaging can range from changing a pressure setting to completely retrofitting motors and actuators to obtain appropriate force. The bottling industry seems to agree however, that though adapting machinery to new packaging can be a painstaking operation, the long term environmental benefits are certainly worth the trouble.

Compostable Bottles and Polymers

For as long as sustainable packaging has been popular, biodegradability has been its poster child. After all, who doesn't wish that they could throw their bottles, wrappers, and cartons out the nearest window and watch eagerly as it crumbles to dust and drifts away? Who doesn't wish for the convenience of littering, without the fear of ensnaring some animal, poisoning the ocean, or leaching carcinogenic toxins into the groundwater? Unfortunately, the technology just isn't there yet. In the mean time we must settle for a "compostable" breed of packaging not without its fair share of problems.

The forerunner of this breed is a material called Poly Lactic Acid (PLA). PLA is a polymerized form of lactic acid derived entirely from corn starch. It is currently being produced by Natureworks, who claims it uses 65% less energy than conventional plastics and generates 68% fewer green house gases [13]. Many companies such as Wall-mart, Wild Oats and Newman's Own have adopted PLA as one of their primary packaging materials due to the supposed environmental benefits, marketing advantage,

and the sociopolitical responsibility. In the words of Newman's Own CEO Peter Meehan "No one has ever gone to war over corn".[13]

Now, unlike a biodegradable material, which would degrade at ambient conditions, PLA must be composted in a controlled environment. Contrary to what is typically publicized, this controlled environment is 140 degrees Fahrenheit with high humidity for ten continuous days. 113 facilities exist nationwide that are capable of processing used PLA, however fewer than 25% are willing to also accept residential waste. When subjected to the conditions of a landfill PLA and PET are both estimated to take between 100-1000 years to degrade.[13] PET however presents a distinct advantage, it is recyclable. PLA's greatest criticism is that it is near impossible to distinguish from PET with the naked eye. In America where most recyclables are still sorted by hand this resemblance can pose a threat to the purity of recycled PET.[14]

PLA works comparably to PET at ambient temperature, but begins to fail once the temperature exceeds 110*F. Joe Selzer, vice president of Wilkinson Industries reports that in a hot car, PLA food packaging such as bottles and take out containers can be reduced to a "pancake". [13] However newly developed food grade modifiers are being developed that are estimated to give PLA a melting temperature in excess of 203* F. [15] Making future PLA viable for higher heat applications.

High Barrier Cellulose Film

In November of 2008, Innovia Films released NatureFlex™ , a cellulose film that boasted the highest barrier properties of any biopolymer to date. Innovia attributed their success to proprietary coating techniques that make their product comparable to co-extruded oriented polypropylene (OPP). The film is made entirely from wood pulp and unlike PLA, can be composted at home. These improved properties have allowed NatureFlex™ to penetrate conventional food packaging markets such as dried

food, snacks, baking, confectionery, pasta, pulses and rice. The film can be produced in thicknesses of 20-45 microns all of which are certified to meet EN13432 and ASTM D6400 composting regulations. [16]

Edible Packaging

One of the more peculiar Ideas for renovating the film and coatings industry comes from scientist and UC Davis Professor John Krochta. Krochta envisions food packaging transitioning to an edible weigh based material, that can be consumed instead of discarded. The weigh could be sprayed onto food as a "glossy coat" or sealed around food as a plastic film substitute. Krochta explains that weigh is a very naturalistic approach to protecting food [17] and has inspired former student Tara McHugh to develop her own edible film.

McHugh is working with the USDA to produce a fruit puree to coat food products. The puree would act as an oxygen barrier within secondary packaging such as a box or carton. McHugh gives the example that her packaging could be used to flavor the product inside such as a "steak wrapped in carrot film", "hams enveloped in apple wraps" or even "buttermilk powder that bakeries could toss right into the mixer"[17]

Meanwhile, Navam Hettiarachchy, a food scientist for the University of Arkansas Division Of Agriculture, has also developed a soy protein based film that he hopes will one day replace LLDPE plastic wrap. The protein based film incorporates nicin, an antimicrobial agent that is harmless to digest. [18]

Recycled Food Packaging

After Starbucks opened the doors for post consumer materials to be in direct contact with food packaging in 2006, [3] several other companies were motivated to embrace their own form of post consumer recycled food packaging. Because of the high risk involved, FDA handles approval for these direct contact food packages on a case to case basis.[19] The FDA's concern lies in the concept of down

cycling in which each time the material is collected and reprocessed it loses a portion of its previous properties. Corrugate and containerboard for example loses fiber length each time it is reprocessed. This reduction in fiber length lessens the amount of bonding between molecules and a result significantly decreases the amount of tensile strength and load resistance. Common food thermoplastics such as polyethylene (PE), polypropylene (PP) and polyethyleneterephalate (PET) also experience down cycling. The bonds holding polymer chains together begin to break apart and crosslink amongst themselves. This cross linking slowing turns thermoplastics into thermoset plastics and reducing tensile strength, optical clarity, and barrier properties. This phenomenon inherent to recycling has been the reason post consumer material is mixed with new virgin material.

100% post-consumer recycled PET was cleared by the FDA for direct food contact in March of 2009. [20] This proprietary sheet stock manufactured by Pine Poly Industries (PPI) claims to have circumvented the negative side effects of down cycling providing a heat and crack resistant thermoform ready material while still being made entirely from post consumer product. The stock is available in a variety of shades and colors ranging from clear to opaque and boasts unparalleled performance and cost advantages. Eco-therm ™can be extruded .010 - .045" thick and has a tensile strength of 8300 lb/in sq.[21] This strength is remarkable consider virgin PET has a tensile strength of 8700 lb/in sq. APPI also reports that unlike a biopolymer, their Eco-therm™ can be recycled alongside any other PET product without the risk of contamination.

The Future of Sustainable Food Packaging

Nanotechnology

Many believe that the future of sustainable food packaging lays not in one particular technology but rather a synergy of those aforementioned. The key to this synergy is nanotechnology, or the science that takes place within the parameters of a nanometer. An unprecedented switch is being made from conventional petroleum based plastic to combinations of organic material known as nanocomposites. These materials mix biopolymers such as PLA with natural fiber from industrial hemp, plant leaves, and even local grass to produce a rigid polymer with superior thermal, mechanical, and barrier properties.[22] Hyperbranching is another application of nanotechnology and is the bonding characteristic of polymer having increased molecular branching between monomers. Hyper branching by means of Synthetic polyglycerols are being incorporated into bio polymers to produce hyperbranched bio-plastics exhibiting exceptional mechanical properties.[22] Nanotechnology is also being used to replace current silica based plastic fillers with nanofillers. This substitution is said to decrease a polymers weight by 45% without jeopardizing the materials properties.[23] The advantage of nanotechnology has allowed scientists to mix and match the properties of different polymers within one material allowing for a new degree of niche specialization for sustainable food packaging.

Kinetics and Active Release Packaging

Kinetics is defined as a “bridge between food science and packaging” [24] Kinetics incorporates studying how a food acts in a package and the corresponding release or absorption of chemicals overtime. This science is necessary to pair optimum materials and design with a specific food. Kinetics aids the evolution of sustainable packaging by providing the scientific backbone to new innovations such as active release packaging.

Active packaging or active release packaging is the ability of a food package to adjust its permeability or barrier properties during transportation and storage. It can either be used to vent harmful compounds out of the package or to transmit antimicrobials and antioxidants into the product, increasing shelf-life. [25]

Intelligent Food Packaging

Radio frequency identification (RFID) is being incorporated into thin-film electronics to monitor the conditions inside of a package in real time. These thin-film electronics will have an array of sensors that monitor temperature, humidity, food age, and even bacteria concentrations. [26] The addition of these low cost discrete sensors will provide a better understanding of how food products interact with their packages, significantly benefiting the study of kinetics, as well as providing an excellent inventory and quality control database to reduce waste.

Conclusion

Innovations in sustainable food packing have come in many forms ranging from simply removing source material to the development of complex nanocomposites. As consumers and industry become more aware of the current environmental conditions, they embrace the concept of moral responsibility superseding convenience and conventional profitability. For the first time industry is moving in a synchronized mass migration away from waste and petro-chemical production forwards toward better, stronger, and more *sustainable* food packaging.

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