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TransFRESH Corporation Salinas, California

# MODIFIED AND CONTROLLED ATMOSPHERE APPLICATIONS FOR THE FOOD INDUSTRY

AN OVERVIEW PRESENTED AT THE 1979
WESTERN FOOD INDUSTRY CONFERENCE

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The basic science from which the technology evolved, can be traced back nearly 100 years. For instance, Frankel in 1889 noted the inhibitory effect of carbon dioxide on the growth of many bacteria. This unique property of $CO_2$ became the foundation of atmosphere applications for fresh muscle foods. In 1930 the English workers Kidd and West published their findings of superior storage stability of apples under reduced oxygen and elevated $CO_2$ atmospheres which eventually led to commercial applications of controlled and modified atmosphere systems for the transport and storage of fresh fruits and vegetables.

Today research is ongoing with thousands of publications available on various facets of the technology. Also today there are literally billions of pounds annually of fresh perishables transported or stored throughout the world under modified or controlled atmosphere systems and the demand is swiftly growing!

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As transportation costs increase along with energy and related costs of food processing, and as world wide demand for fresh, premium quality foods increases, new and improved applications for modified and controlled atmospheres are rapidly appearing along with an increased demand for the existing technology.

The specific systems offered by TransFRESH Corporation, evolved from a very basic initial concept in the early 1960's of the Whirlpool Corporation whereby they wanted to incorporate controlled atmosphere in the vegetable crisper of the home refrigerator and in turn hopefully sell more refrigerators. That particular idea didn't fly but Whirlpool persisted and the concept eventually grew into what is called the TECTROL Atmosphere system. (TECTROL is a registered trademark which translates into Total Environmental Control.) TransFRESH Corporation now owns the system and has been marketing, perfecting and developing TECTROL controlled and modified atmosphere applications since 1966. Today we supply the atmosphere systems and technology for shipping or storing over 2.0 billion pounds of fresh produce and muscle foods annually.

Simply stated, modified or controlled atmospheres consist of various mixtures of naturally occurring gasses designed to supplement good refrigeration during transit and storage of many perishable commodities. The primary objective being to facilitate a premium fresh quality product with a maximum available shelf-life upon arrival at the end market.

Specially tailored atmospheres are effective through a variety of mechanisms, depending primarily on whether the commodity is of the respiring or non respiring type. Respiring products, like fresh fruits and vegetables, benefit primarily from the slowing, by proper atmosphere applications, of respiratory rates and related undersirable metabolic processes. Holding back maturity or delaying the ripening process is a primary benefit.

Properly tailored atmospheres for respiring perishables include component gasses that also slow most mold and fungal growth. Depending on the commodity, various other benefits of atmosphere applications can be quantitated.

It is important to note that resiring products can have dramatically different atmosphere requirements from commodity to commodity, demanding sound knowledge, responsible handling practices and careful control.

Non-respiring products such as meat, fish and poultry benefit primarily by the inhibitory effect of the component gas $CO_2$ on the growth of the common spoilage bacteria that normally grow at refrigeration temperatures. Preventing bacterial spoilage, however, is often only half the battle. Anytime you extend the fresh shelf-life of most muscle foods and particularly most seafoods, the most difficult problems often involve undersirable post mortem biochemical and related physiochemical changes that can have an adverse effect on quality. These problems are no less complex than those associated with actively metabolizing perishables. TransFRESH has therefore gone beyond the gross application of $CO_2$ and designed gas mixtures that are also effective in maintaing the biochemical and physiochemical stability of fresh muscle foods. We have made and continue to make exciting progress in this area, through our own research efforts and in cooperation with public research entities such as the Institute of Marine Resources U. C. Davis. This particular facet of atmosphere technology will present new frontiers and opportunitites to the scientific and industrial communities alike, particularly in the seafoods area.

It is important to note that whether the commodity is of the respiring or non-respiring type, good temperature control before and during controlled atmosphere applications is absolutely essential. The technology will not cure the effects of poor inherent quality or poor handling. The quality that comes out can be no better than what went in. It is unfortunate that our technology is sometimes abused by a few who use it to get weather damaged, poorly handled or otherwise over-the-hill product to market when it would normally not make it. The technology gets it there in acceptable condition but such products will often deteriorate rapidly once removed from atmosphere.

The terms CA or controlled atmosphere and MA or modified atmosphere are worthy of some explanation. The primary difference between modified and controlled atmosphere systems is the method of maintaining the gas atmosphere.

In a controlled atmosphere system, the atmosphere is constantly monitored and/or replenished. Representative of the controlled atmosphere system in our business is the TECTROL generator, a mechanical device, that produces high volumes of a desired atmosphere as needed, for use in fixed storage cold room applications on fresh fruits and vegetables.

Conversely, modified atmosphere systems are generally a <u>one time</u> application of atmosphere relying on enclosure airtightness or compatibility of the gas

mixture with the product to maintain the proper ratios and concentrations of gasses. Injecting a gas mixture into a bag of say fresh chickens and sealing it, is an example of a modified atmosphere type of application.

Today we employ the modified atmosphere concept for our distribution and transportation applications, however, initially we began with the rather cumbersome controlled atmosphere approach. Our first transportation applications were with piggyback trailers equipped with gas cylinders and a considerable amount of additional and rather sophisticated hardware items. On the road, as the atmosphere concentration decayed, due to normal leakage electronic controllers automatically valved additional gas into the trailer. This system was satisfactory as long as only relatively simple atmosphere mixtures were required and trips were not too long. Also, the excess weight and space requirements of such a system and the related costs quickly pointed out the need for a new approach.

With the philosophy of simpler is better in mind, the modified atmosphere approach to transortation applications was developed upon the principle that nearly airtight transortation equipment must be used in combination with inexpensive, nearly maintenance free pieces of hardware to facilitate servicing and proper control of a modified atmosphere.

Working closely with trucking, railroad and steamship companies and the manufacturers of the transportation equipment, the proper construction features and modifications to existing and in particular newly manufactured equipment were worked out. The end result was tighter, better insulated and therefore more efficient refrigerated transportation vessels with the added capability of being able to accept and maintain modified atmosphere.

In addition to tighter construction and foam in place insulation, there are also three pieces of hardware that we manufacture and supply to container or trailer manufacturers for installation during construction of the equipment for their customers. This hardware consists of two four inch port assemblies, one installed on the forward bulkhead and one aft. These ports facilitate flushing of the container with atmosphere, sampling and rapid resealing with expansion plugs.

The third piece of hardware is an extruded aluminum track around the inside of the doorway. The track facilitates rapid installation of a disposable, heavy duty plastic, gas impermeable, doorway curtain. This curtain provides an airtight seal to insure against leakage around the container door gaskets.

The hardware is simple, so it would appear that the difficulty would be getting the tighter equipment built or modified, but today there are over 20,000 containers, trailers and railcars in use that have been modified or manufactured to TransFRESH specifications with roughly 2,000 more each year being produced.

Briefly, the equipment is serviced as follows: First, prior to being released for use, each container is literally pumped up and the leak rate measured at a specific positive pressure. If the equipment does not meet specifications, it is not authorized for modified atmosphere use until corrected.

Prior to injecting atmosphere, the load is inspected for proper pulp temperatures, bracing and stacking patterns. The stacking pattern is important to insure good air circulation to remove the heat of respiration. Drains are plugged or, for wet loads, U-traps installed and then the doorway curtain is sealed in place by means of a semi-rigid plastic ribbon which is snapped into the track over the curtain. Non life-supporting atmosphere warnings are posted in the appropriate languages and the van doors are sealed with another warning attached.

For atmosphere injections, the ports are removed and a servicing unit is hooked up to the forward port. These units are equipped with atmosphere blend panels designed with "fail safe" features to insure consistantly correct gas mixture deliveries. The desired atmosphere is flushed into the equipment for the proper time and prior to replacing the rear port, the atmosphere is sampled and measured before the load is released.

Another transportation system we offer, is called the pallet bag system, used by shippers of strawberries, cherries, figs, cauliflower, etc. A pallet of chilled produce is covered with a plastic bag which is sealed to a specially designed, disposable base built into the pallet. Atmosphere is injected and the bag fully sealed. This versatile system facilitates independent handling in conventional refrigerated transportation equipment and in mixed loads of commodities requiring different atmosphere mixtures. Last year, over 100,000 pallet bags were serviced containing over 140 million pounds of produce.

The last system I will cover before discussing Alaskan salmon, is our newest one. It operates around the smallest units that we presently service, 10-pound bags. It is currently called, for lack of a better name, the bag in a box system. It employs a packaging machine, which pulls a vacuum on the bag of product, replaces the vacuum with a specific gas mixture and then seals the bag which is then boxed for shipping. This system, employing our most recently developed atmosphere for chopped prepared salads, is being used to ship ready-to-eat product to rapidly growing institutional markets.

By integrating sophisticated multi-gas atmospheres with the specific functional properties of various packaging films, dynamic and extremely effective fresh food applications can be achieved. The future potential for this type of application is tremendous.

Roughly 380 million pounds of salmon were harvested in Alaska last year; most of it in a four week period. It used to be that most Alaskan salmon was canned by strategically located canneries capable of stuffing a lot of salmon in cans over a short period of time. - But, markets have changed and the demand for fresh and fresh frozen salmon has increased dramatically while the demand for canned salmon has waned. Many canneries have been closed and freezing capacity in Alaska is relatively limited especially in many remote, salmon-rich locations. As a result, each year, millions of pounds of fresh salmon are flown out of these remote sights by aircraft of every discription from Cessna 150's carrying a few hundred pounds to C-130 Hercules carrying 45,000 pounds. - Much of this fresh, often unbutchered

salmon is transferred in Anchorage to airplanes bound for Seattle where the *fish* are processed and frozen or marketed fresh if they have any fresh shelf-life left after this intricate and often delay frought trip. This process is very expensive, not including in-transit spoilage and quality losses, and during peak periods, there isn't enough airlift capacity available to move the fish fast enough to negate even greater spoilage losses.

But there are container ship lines servicing Alaska that call several times a week in Anchorage and Kodiak and as a matter of fact, most of the fresh meat and produce going up to Alaska is shipped under TECTROL Atmosphere in refrigerated seavans that often return to Seattle empty. So, the transportation equipment was available, the stage was set and fortunately, we had conducted our research on salmon years earlier both in-house and in cooperation with the National Marine Fisheries Service in Seattle. We had also supported work here at U. C. Davis in the Institute of Marine Resources. So, in 1977 when we were called by a knowledgeable salmon producer in Alaska who knew he would be unable to keep up with the fish, we were prepared and confident that we could help solve his problems. Two commercial scale test shipments were conducted that summer in cooperation with the container ship companies, National Marine Fisheries Service and the salmon producer. Everyone was very pleased with the quality of these shipments and plans were made to offer our services in Alaska on a regular basis beginning in 1978. In the meantime it became clear to us that chilling capacity would be the limiting factor for shipping salmon under modified atmosphere out of Alaska. Refrigerated seavans are designed for maintaining a chilled or frozen product only and not for the initial chilling or freezing. So we put together a processing and chilling facility in Anchorage to correctly handle salmon for surface shipments under modified atmosphere.

Last year roughly 2.3 million pounds of fresh dressed and chilled Alaskan salmon was shipped under TECTROL Atmosphere from Anchorage to Seattle. This year we expect between 8 and 12 million pounds as the industry learns from our somewhat unique facility how to handle fresh salmon for surface shipping.

Our facility was unique in that we emphasized rapid immersion chilling which is essential not only for slowing down undersirable autolytic enzymatic and chemical changes in the fish but is also necessary for preventing dehydration and inhibiting the growth of gram positive spoilage organisms that do not grow significantly below 38$^{0}$F. The freshly dressed salmon were conveyed into baskets placed in small wash tanks at the end of each line. When the baskets were full (about 500 lbs) they were hoisted into the chill tanks containing refrigerated, circulating fresh water. In the chill tanks the baskets were automatically conveyed at a speed calculated to chill the fish throughout to a temperature no greater than 36$^{0}$F by the time they reached the packing table. The chilled fish were then boxed and lightly iced for the purpose of maintaining a humidity level sufficient to prevent dehydration in transit. Boxed fish were then loaded into the refrigerated vans, vans were sealed, atmosphere serviced and the van released for loading on the container ship destined for Seattle.

*Transit* times or days under atmosphere prior to fresh sale or freezing in *Seattle* ranged from 5 to 12 days. Much of this fish was sold fresh. Research and now commercial practice has demonstrated just how effective the technology can be in extending the premium fresh quality shelf-life of responsibly handled fresh salmon. For instance, an average reasonably well handled salmon will normally spoil after 8 to 10 days out of water. Dr. Harold Barnett of National Marine Fisheries in Seattle routinely holds salmon under modified atmosphere for 21 days in his studies with subsequntly good taste panel acceptance. We at TransFRESH do not recommend holding salmon in commercial practice much over 14 days under atmosphere which (if the fish was well handled prior to and after atmosphere application), should leave 4 to 6 days of quality shelf-life after removal.

We are presently restricting our commercial seafood applications to systems that have well maintained mechanical refrigeration units as an integral component and to systems that have a defined range such as the Anchorage to Seattle circuit. The reason being that prolonged temperature abuse situations must be very thoroughly investigated. We have been and are currently involved in such investigations.

The future for modified atmosphere is very exciting. The potential in the rapidly developing seafood industry alone is tremendous and we are making exciting progress with other seafood commodities including various bottomfish species, crab, halibut, shrimp and so on. New packaging applications are being developed and we have also developed new and dramatically effective atmosphere mixtures and systems that should literally revolutionize some of our existing food distribution and handling systems resulting in more efficient operations and higher quality fresh and in some cases processed foods at lower cost to producers, processors, wholesalers, retailers and consumers alike.

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