increased capital cost for new packaging machinery, increased costs of packaging materials, some consumer resistance to the headspace and unsuitability for frozen storage.

The reluctance of the wholesale and retail food industry to use C/MAP appears to be due not to technical problems but rather to other economic and social concerns. The equipment and packaging materials are currently available for commercial C/MAP of FRM. Any FRM packer with sufficient capital who wanted to could enter the market with extended shelf life of C/MAP FRM.

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Discussion

Session One

R. Field: I have a question on something you just passed over. You indicated the FDA did not approve carbon monoxide for use, and I assume you're referring to just red meat. I'd like to hear your comment about carbon monoxide in produce, like the vegetables and perhaps some of the fruits. Is there any concern about safety in the vegetables as far as use of carbon monoxide? What level is it used at? How is it used there? My question is a concern, of course, because if we had that in red meat we could solve the color problem.

J. Hotchkiss: Something like 100 ppm has been addressed to FDA for red meat and they have specifically not approved it, not based on safety problems necessarily, but based on concern that that is a reconditioning process. In other words, it's something that might fool the consumer. It is specifically approved and used in cut lettuce. I don't know the exact process. As I understand it (it is a proprietary process), carbon monoxide is used at the 1% level. As you well know, carbon monoxide complexes iron stronger than oxygen, in addition to being red in color. It also inhibits cytochromes and will slow or inhibit respiration, which is a key element in produce. As I understand, the Techtrol Process is used by Transfresh in California for cut lettuce. I haven't seen the science on it to know. I worked a fair amount with cut lettuce, but we've never run across anything published that convinced us that it was very effective, but lots of people are buying it and using it. And I understand there is some work going on to expand its use to other cut products. Cut produce has problems because as soon as you cut it up, whatever you do, the respiration rates go through the roof, and so in order to get any kind of shelf life out of it, one of the things that you have to address directly is slowing that respiration down. And carbon monoxide will do that. It's in the Code of Federal Regulations as being approved for that, I'm quite sure. I don't think it will ever come for meats. It would certainly address the color issue; and what Excel is trying to do, for example, would become kind of moot. You wouldn't have to reeducate 240 million shoppers minus a few meat people.

D. Kropf: One comment first, Joe, and that is you are

asking the barrier to not using more modified-atmosphere packaging. I think if we have any kind of a long haul, I would be concerned about the fact that you have a truck filled half with gas and half with meat. My question is really with regard to headspace volume to meat volume. Do you have a feel for how low we can go? Let's say if we're using 80% oxygen, 20% carbon dioxide in the package like the Europeans do, and we're going for two weeks shelf life, could we possibly get by with a headspace equal to the meat volume or half of the meat volume? Do you have any feel for that?

Hotchkiss: That would be a really good research project to get some poor graduate student to try that, try 50 different rations. I would say, based on the work we've done, that a 1:1 ratio would be a bare minimum and it would surprise me if 1:1 would work, but I haven't done those experiments, so I don't know. For that kind of shelf life, in the neighborhood of two to three weeks, I think you'd be more in the range of one and a half, but that's strictly a guess. I don't have very good data. Most of the research we do is with a large head volume because we're interested in what happens to the product under some kind of stabilizing conditions. Deane, have you guys done some stabilizing work along that line? I would guess that some of the packaging companies have.

D. Galloway: Yes, I think you're right, Joe. To get that kind of shelf life, I think 1:1 wouldn't be adequate. You'd probably get about half that shelf life with 1:1, which is typically what they're getting in Europe, about 6 to 7 days shelf life for that kind of package, rather than the 14 that you mentioned.

Hotchkiss: That brings up your point about if you're doing this in Iowa or Texas or wherever you'd like to centrally package beef and you want to ship it to some place else, you're shipping a lot of carbon dioxide at atmospheric pressure, which can be a pretty expensive process, I suppose, to ship all that dead space around. I think that is one of the limitations of the system.

J. Price: Your data shows clearly that *Listeria monocytogenes* is largely left alone. What other pathogens under these conditions should we be concerned about? Are there others that behave in a similar manner or others that are controlled?

Hotchkiss: It's kind of a trade-off. For example, *Salmonella* are somewhat controlled by the elevated carbon dioxide. It's kind of a wishy-washy thing in the literature and we've done some work on it. That's because it's not very effective. It doesn't seem to influence it one way or the other. *Staph aureus* is very well controlled actually, surprisingly — at least on poultry and some of our other products. One of the problems with *Listeria* is that this work was done under what you would consider pretty good refrigeration, 44°F, so some of the other pathogens that will grow at those kinds of temperatures are a concern. The work just hasn't been done. There are very few people doing any kind of safety work with modified-atmosphere packaging. We've gone through a number of them and we're now kind of backtracking and going to look at some of the others. Of course, if you're in a situation where you're strictly anaerobic, particularly if your animal swam before you decided to package it, and may be contaminated with *Type E,* I think then that makes you nervous because that one grows at refrigeration temperatures. The organisms I think that are of the greatest concern are those that will grow even if everything in the system works right, as in this case. So, yes, I think we're going to see some more, but there are just not enough people working in that area. I hope some of you can get interested and do this. Pick your favorite pathogen and favorite slice of meat and go to town.

D. Naumann: To what extent have we determined the effect of carbon dioxide, whether it's directly carbon dioxide on the organism or the effect of causing it to be more acidic, which reduces activity?

Hotchkiss: I would guess it's about an 80:20 split in the literature, the 20 being those that believe the effect of carbon dioxide is due to its solubilization in the auqeous phase of the product and thereby lowering the pH. We took surface electrode pH's until we looked like a chicken trying to do that, and even with very high carbon dioxide, we could never get more than about a 10th of a pH unit difference in the surface of the meat. As probably everyone in this room knows, meat is a pretty good buffering system and you can't get it to change. On the other hand, the changes in the microflora are dramatic, so I put no credence in the external pH at all. I believe that it is something more fundamental than that and there is some good literature on that. Now we get to talk intracellular. It certainly could be pH intracellular, particularly gram negative organisms may in fact have the ability to concentrate carbonic acid and thereby lower their internal pH. That's one theory and there's some evidence to support that. Another theory is that one of the decarboxylative enzymes is inhibited simply by mass action, that is, carbon dioxide is a product of that enzymatic system, so just the fact that you've got a lot of carbon dioxide around inhibits that. There has not been a clear answer to mechanism in the literature. I think it would be a very good, basic biochemical project to determine that, because it might give you some insights into how to better use carbon dioxide to inhibit spoilage organisms.

D. Bartholomew: Can you get an oxygen concentration that is low enough that it would give you color problems? On the other end of the scale, can you get enough carbon dioxide in the system that it would give you color problems?

Hotchkiss: Certainly, you can get too little oxygen in the system. It's better to have none or a lot and stay away from the partial pressures in the range of 2 to 3 to 4%. Then you get metmyoglobin problems. That seems simple and it's right. No one in their right mind packages red meats in an atmosphere of that concentration, but you have to remember that lots of people don't understand that. They read that there are perfect barriers and think that whatever they put in the package is going to stay in the package. You may put oxygen in the package and then it permeates out and some gets consumed by the product, so you want to stay away from that low level. The high end on carbon dioxide is a little bit more controversial in the literature. We have, working with poultry, found that high levels of carbon dioxide appear to be detrimental for myoglobin color. Fortunately for the poultry people, poultry is not judged for myoglobin, so color is not a serious problem. It actually poses a little bit of a problem for yellow skin color as high carbon dioxide will bleach the yellow color, so there are some problems. The situation with color in these modified atmospheres, at least in the literature, is not clear. You can find support in the literature for whatever your opinion is, but my own opinion is that high levels of carbon dioxide are detrimental to myoglobin stability.

Kropf: This question could be directed at either one of you. Wtih the gas packs of pork loins and especially with the very close trims that we're getting now, we sometimes have green loins or kind of a green-dull gray surface on the loins with high carbon dioxide. Do you have any recommendations to overcome this problem? And then I think some people have been adding oxygen, perhaps to overcome it, but then they have a problem after they slice the pork chops from the loins. What light can you shed on this?

Hotchkiss: I don't have an answer for you except it's my understanding that whenever I hear that meat products are green tinted, I always think of sulphur-producing organisms or things that produce hydrogen sulphide. I really haven't experienced that.

Galloway: I guess I'd have to get more details, too, Don, but one thing that can have an impact is the barrier of the film that's involved. In fact, an earlier question talked about a low level of oxygen and you can create that kind of condition with a film that doesn't have a good enough barrier to oxygen. It can be a real problem. I don't know if that's involved in this particular situation or not, but you can get some discoloration, as Joe commented before. It's common in beef, or can be, particularly in some of the work that's been done with retail beef. If you use films that don't have the right level of barrier, you can get that metmyoglobin condition and you can have a discoloration problem from day one. The solution to that one is to have an improved barrier to oxygen so that you don't have that very low level of oxygen partial pressure, but instead you go below that level and back to the deoxymyoglobin color. I don't know whether that's involved, Don, in this pork situation or not.

Kropf: I guess you could do that, yes.

Galloway: That can occur under certain circumstances; I know that.

R. Kauffman: I'd like to ask you how much of the information that you have provided to us this afternoon also relates to a product that's lower in temperature than what you're talking about — we'll say below freezing?

Hotchkiss: You mean by below freezing that the water in the product is frozen?

Kauffman: Yes.

Hotchkiss: Very little, because if you have very little or no free water, then you don't have the microbiology problem and you're wasting your effort, although there are commercial people out there taking frozen foods and modified-atmosphere packaging them in a variety of things. I'm never quite sure why they're doing that instead of skin packing them or something. There's a fish product out that's doing that. They kind of say that's a backup process, but other than to inhibit oxidation in a product, I see no reason for using modified atmospheres. I really don't see any reason for doing that in that case. If oxidation is a problem in a frozen product, you want to skin pack it or vacuum pack it somehow in a good barrier material, and it's a real long shelf life product. That's my opinion.

Galloway: Yes, I think there are more problems with modified atmosphere packaging in frozen conditions. One of the big problems is dessication and cavity icing, or freezer burn, whatever you want to call it, where you've got an opportunity now in a free, open package for the product to lose its moisture and to crystallize and condense on the inside of the package. As we all know, that moisture doesn't get reabsorbed when you thaw the product. So vacuum packaging is really the preferred method for frozen products for that reason.

Naumann: Deane, most of the modified packaging in Europe has been in individual retail packs. Have they done anything on master packing with modified atmosphere?

Galloway: I guess I'm not as familiar with that as I am with the retail operations. I'm not aware of any large-scale application of it. I'm sure they've done research work with it. One of the differences in Europe is, of course, the distribution required. Most of the countries are like states here. In fact, the 6 or 7 days of shelf life that we were talking about earlier for a lot of the things that they're doing there are adequate. So, I would think that, for the same reason, master packs wouldn't be as valuable for them from a distribution standpoint. I'm not aware of a large-scale application, no.

Hotchkiss: You brought up Europe which always gets brought up when I talk about this. Let me make a comment about that, because I think it's important to consider. Because the distances and the timeframes are much shorter in European markets, the Europeans embraced this technology not as much to get shelf life, so that they have to distribute less often, but rather to improve quality. If you have two products that start out at exactly the same quality, but one product has a longer shelf life — let's say shelf life of 25 days compared to 10 days, or whatever numbers you want to pick — the longer shelf-life product will be a higher quality product at day 3, way before either of them have reached the end of their shelf life. Consequently, they, particularly Marks & Spencer, use this technology not to try and get things that last forever like the pasta people. You know, the pasta people were at 60 days with the modified atmosphere, so-called "fresh" pasta — one of the real marketing geniuses. They've tried to convince all of us that 60 day shelf-life soft pasta is fresh. I call it high moisture content and somebody always comes up and says to me, that's fresh pasta. But they don't do it to do those kinds of things. Their interest is in improving the quality of their products and so they have no real need to go to a master-pack, long-distribution system. They want something that will hang in there in distribution and retail display, and give the consumer a few days if they want to keep it in their refrigerator.

D. Huffman: Just a follow-up comment on the Marks & Spencer, I think you're right on target with what you say about that. I think in addition, they don't have the same paranoia that we have in this country about price. I think it's a paradox that you take something like Nutrasweet® and you have, Deane, lots of money tied up in packaging with very little product there, where we have a very valuable product and we're absolutely concerned about every penny of price in transportation and packaging and at the retail. Whereas, Marks & Spencer is strictly upscale and price is not a consideration.

J. Hodges: At the end of your comments, you indicated that adoption of this technology is possibly due to economic or societal concerns. You touched on the economics with transportation costs and those kinds of things. Would you care to speculate on what the societal concerns are?

Hotchkiss: I mentioned that; maybe some of you didn't catch it. I don't know this for sure, maybe some of you,

particularly in the industry, know. As I understand it, there is serious meat cutter union opposition to this, because they know that if you centrally package products, you get rid of the meat cutters and you do something important there like sell blue jeans or cough remedies or the kinds of things they do in grocery stores these days. I've been told that that has been a factor in some of the commercial tests. As you know, there have been some commercial tests — fairly large by my standards — huge commercial tests of this process and when I talk to those people over a couple of beers and find out what the problems were in that test, we never get technological problems. In other words, the meat looked good, it kept well, it was great, but we had other kinds of consumer resistance to it. There's a little bit of question, for example, in the back of my mind, particularly in the U.S. and I assume so in Canada by walking around this university, that packaging has got a reputation as being a major problem in the solid waste stream and that's going to grow. Apparently, it's going to be a problem here and it's certainly a problem in the U.S. So that's a kind of societal problem that I wonder about. When you put this headspace on top of a piece of meat, what is the consumer going to think you're trying to do to them? So there are those kinds of problems, or maybe they're not problems. Some of you who have to deal with this on a day-to-day basis probably have a better idea.

G. Trout: One thing you didn't address when you were talking about modified atmosphere is some of the work that has been done in New Zealand recently where they're using 100% carbon dioxide and storing it at just below freezing (at −1°) to try and extend storage of primal cuts not just for a few days but up to 16 to 20 weeks. They seem to be very effective at that. Would you like to comment a little bit about that?

Hotchkiss: Yes, I'm familiar with some of that work, and you're absolutely right. I guess I indirectly mentioned it. The effect of carbon dioxide is directly related to its solubilization and solubility. As a matter of fact, there is a very nice review written on this where someone has gone back into the literature and corrected the amount of carbon dioxide for this partial pressure to even it, and if you bring it all to the same partial pressure you see no effect by increasing amounts. So the colder you keep the product, the more soluble you keep the carbon dioxide in the product and the longer the shelf life. You really get a kind of double benefit from that. That is, you get the normal effect from such a cold temperature plus the effect of increasing solubilization of a bacteriostatic agent. The problem with that system is that it's a fine storage system, but at least in the U.S., and I assume in Canada too, it's a very unrealistic distribution or retail kind of system. If you have control of your own storage system, that's fine. Even then the Cullinova experience in the U.S. (Cullinova was a modified-atmosphere package-dinner system which was owned by General Foods from A to Z — they even went into the stores and redid them) shows that temperature control in distribution that you experience in a large country is quite difficult.

Trout: The reason I'm interested in theirs is, of course, for export markets where you have to ship products overseas where you can't control the temperature. Most of the conventional vacuum packaging cannot hold the meat long enough for it to be fresh or in good condition when it gets to overseas markets, so that was their main interest. I understand that to some extent, the U.S. is interested in that too because of their interest in exporting meat, particularly to Japan.

Hotchkiss: The Australians actually invented modifed atmosphere packaging of meat in the 1930's. That's the way they got hanging beef to the U.K. in the 1930's, as I understand it, by using carbon dioxide. You can go back in the literature and find reports of the Australians doing that in the early 1930's. It's not a particularly new idea.

Session Two

N. Marriott: Many of us are very concerned about some of these processes such as sous vide where it's being done at individual retail stores with very little control. It appears to me that sometimes some of us are going to have to stand up and be counted and, in fact, some have already done this. I guess my question to you is, what do you think is appropriate for some of us who owe the industry and the public the educational information related to processes such as this?

J. Hotchkiss: Yes, I've been personally very involved in the issue because the state of New York, my home state, came out and nixed this. Let me answer your question in a rather broader sense. What is happening is that there is a whole range of new technologies coming on line, not just modified atmosphere, but all kinds of packaging technologies, and that's really the reason I'm interested in this. These new technologies are changing the way we think about the timeframes and maybe the risks with these packaged foods. For example, I believe that's true for a company in Virginia who is modified-atmosphere packaging in 100% nitrogen, as I understand it, in a system that guarantees 1/2% or less residual oxygen for hard-cooked and peeled eggs. The product is never reheated. I don't think anybody buys a hard-boiled egg and reboils it if the shell has been taken off. So you wonder about the hazard of that. Maybe they are a very good company; but the problem is that a lot of these technologies are very cheap and you can put them into very small "mom-and-pop" operations, where they have no technology, or you can put them into very large operations. You can't blanketly say "This is a bad idea, let's don't do it." I said that about sous vide, but Culinary Brand in California has done more microbiology with the sous vide process than all of us in the room are going to be able to put together in the next year. They really know what they're doing. On the other hand, there are lots of small "mom-and-pop" operations, so we're grappling with all these issues. I think that people who are concerned about food safety, particularly academic people, have to stand up and say the things I tell the retail grocery stores, who want to vacuum package products in the retail store. They question why regulatory agencies should treat them differently. For example, the state of New York won't allow them to do their own nitrite curing, then vacuum package those products. You have to stand up and say that if they want to be like the USDA-inspected plant, then behave like a USDA plant. So I agree we've got to stand up and tell them that, even though they may not like to hear it.

D. Cornforth: Could you define this sous vide process a little more? I'm not that familiar with it.

Hotchkiss: Those of you who are *"C. bot.* folks" are going

to cringe when I describe this process and the reason for it. Just look around and you're going to find out who the "*C. bot.* people" are because they are going to be nervous as I answer this. There are a lot of interesting things about sous vide. It's French. Doesn't it sound nice? It literally translates as "under vacuum." Can you image going around trying to sell a process called the under-vacuum process? I thought what we need for irradiation is a nice French word and people would be more willing to accept irradiation. So I asked one of my French students how do you say "irradiation" in French and they looked at me and said "irradiation." Sous vide is a French process in which you take either a partially-cooked or maybe even a product not cooked at all, usually a very upscale entree (I'll explain why that is), perhaps something like a flounder stuffed with crab meat; you put a single serving in a high-barrier package and pull a very high vacuum on it, maybe 28 to 29 inches of mercury so you take just about all the air out of the package; then you low-temperature pasteurize that in either an oven or boiling or in even just hot water. You might heat it for a few minutes at something under boiling water temperature and you essentially kill most, or all, of the vegetative cells in that process. Then you refrigerate it and store it until you want to serve it, when you reheat it; maybe by dropping it into boiling water. Now, why do people want to do that? The reason is because it produces a very high quality product and it's surprising the kinds of products you can process that way. What can occur, then, in your restaurant is that you can have your expensive chef come in at 5 a.m. on Thursday morning and make 45 or 50 servings of flounder stuffed with crab, take them through the sous vide process, put them in the refrigerator, and leave. Then, when dinnertime comes all through that week and the next two weeks, every time a guest orders the flounder, a helper at $3.00 an hour pulls it out of the refrigerator, drops it in boiling water, cuts it open and puts it on the plate. It's a money-saving practice, particularly in the food service industry, and it will produce a very high quality product. Now those of you who know about *Clostridium type E* say "wow — fish, refrigeration temperature, two weeks" — you're a little worried about that type of thing. The FDA has forbidden the restaurants, who most want to use sous vide, to do so, but are allowing food companies to do it. There are two large manufacturers who are using it: Culinary Brands in San Francisco and Cryovac Food Service Division, which has built a plant in Maryland to do it. It's a process that can be done very cheaply. If you really want a good piece of equipment, you can do it for $2,000; but if you want to do it with something cheap, you can do it for about $300.

S. Moore: What efforts have been made in getting carbon monoxide approved for modified packaging?

Hotchkiss: FDA has been approached about using something like 100 ppm carbon monoxide. Obviously, that would take care of the color problems in all this and life would march along nicely. FDA has specifically forbidden that, not on the basis of it being a safety problem per se, but rather a reconditioning kind of problem or a deceptive or economic kind of practice. So, carbon monoxide has been specifically addressed by the FDA. I used to work for the FDA, and I very much doubt that that would be changed unless somebody came up with a really strong argument. Carbon monoxide is permitted in cut lettuce and a couple of other cut-produce products. Carbon monoxide, in addition to binding myoglobin stronger than oxygen, also inhibits oxidative cytochromes in respiration. When you take produce and cut it up, the respiration rates just go through the roof. They're high anyway in something like lettuce, but they just go crazy when you cut it up. So carbon monoxide is used in California for cut lettuce; then it is shipped around the country. I believe the process is called the Techtrol process. It's a patented process to Transfresh Corp. I don't know exactly what the process is. I understand it's 1% carbon monoxide, a lot of carbon dioxide, and some nitrogen to keep it from collapsing.

J. Carpenter: The Australians are shipping fresh meat and getting a 100-day shelf life on it. Do you know what kind of packaging they're using on that?

Hotchkiss: I don't specifically. As I understand, it's a primal or subprimal application, not retail. They're using a very high barrier system. What they have done is line up all those variables that I've talked about and said "Let's go to the hill on all of them to get this long shelf life." They're using something like 29°F, which has two benefits. It increases the solubility of carbon dioxide in the tissue and it lowers the temperature so you're getting a double benefit. They're using a very high barrier material, as I understand, and very good temperature control and they're using 100% carbon dioxide. Now, the thing that I have to say about that is that they have their own system they've bought into and they can get those kinds of shelf lives. You can do that kind of thing, but you have to have very careful control of your temperature and of your distribution system. Most of the way distribution is set up in the United States is that as soon as it leaves your plant's door, you've lost most of the control, if not all of the control, of that product, and it's very difficult. One of the problems for people who have experimented with this technology has been to get the next person down the line, the next company, to use as much care or do what you want them to do with your product. As you noticed, for example, on the Wilson system that I showed here, there were all kinds of guidelines about temperature control. So while that kind of works, to get those kinds of shelf lives you really have to go from A to Z. We have kept products actually at warmer temperatures in the 30's, for 65 to 70 days, but obviously in a system we have very good control over, using recorders and those things. The more shelf life, the more control, but they're doing it.

D. Galloway: I would just comment specifically, John, to your question on what packaging material they are using. It's not anything unusual. I can tell you that because we have analyzed it and it's standard kind of packaging materials. I think the key is what Joe was talking about — the temperature control which we all know is very important — and the combination effects of the low temperature with the carbon dioxide that they use. So, it's not in the packaging materials. I can assure you of that.

S. Rickert: My understanding is that also another key factor in this long shelf life of the meats from Australia is to use meats with pH of 6 or less. Quite important.

Hotchkiss: Yes, I kind of glossed over that. Of course, the longer the shelf life, the more control over the whole system, but the product is really the first variable to start wtih because that's the one you should have the most control over and know the most about. You can't cover up, with most of these systems, for lack of control of your product. As a matter of

fact, the major use of modified-atmosphere packaging is not to give long shelf life, but to give better quality to products. That is what has come out of its use in the Marks & Spencer stores. Let me illustrate that. Let's say you have two packages of the same product that have the same quality at the time of packaging but one of them has a 25-day shelf life and the other has a 15-day shelf life. When that product is purchased at three days, the 25-day shelf life product is higher quality than the 15-day shelf life product. That's the philosophy behind Marks & Spencer, for example, and that's the philosophy behind some of the other higher value-added products that are distributed in the United States today — some of the cooked and breaded kinds of products. Certainly, this whole thing about the importance of the product is really primary, I think.

G. Wellington: I'm a little confused as to the extent to which this system is in use. You mentioned that in New York State you can't use it, but I'm not quite sure.

Hotchkiss: I'm sorry. I wasn't very clear about that. In New York State, you can't use it at the retail level or the restaurant level, but if you're a qualified manufacturer of products, that is, you're either USDA-inspected, or Ag in Markets, or FDA-inspected, you can use it. Now, the extent. Somewhere between 15% and 20% of all poultry is packaged in master pack systems under modified atmosphere. It's back flushed with 100% carbon dioxide, which brings the package to about 75% carbon dioxide, 20% nitrogen and 5% oxygen. The latter are the numbers we usually hear for our poultry. The Europeans, in general, are more committed to modified-atmosphere packaging. It is being used a little bit in Canada because Marks & Spencer has come into Canada. They are pressing some Canadian red meat processors to use that system. There are a few fish companies that have played with it. Probably the widest application of the technology is in the so-called fresh pasta. I love that — fresh pasta — the soft pasta you buy in the store. It really has a 60-day shelf life, at least the manufacturer of the equipment guarantees a 60-day shelf life, but they've convinced us all it's fresh pasta. That is probably, singly, the largest volume product that is all across the United States. It has been estimated by those who study such things that the dollar volume of food packaged in modified atmosphere far exceeds aseptic packaging in the United States, and I think that is probably right. So, it's a widely used technology. It's here, but in very limited use in red meat.

Galloway: Yes, I'd like to add a couple of applications that we tend to forget about. In the cheese area, for example, all of the packaged shredded cheese is in modified-atmosphere packaging and has been for years. A lot of the chunk cheese, like that in so-called Hayssen packages, is modified-atmosphere packaged. Also, there are some thin-sliced luncheon meats, Buddig-type meats, that are packaged in a modified atmosphere. Each of these is in a modified-atmosphere package for a specific reason. For shredded cheese and thin-sliced luncheon meats, the purpose is to maintain integrity of the product, which would be lost in a vacuum package because of product compression. So, there are some we forget about, that have been there for years. There are a lot of new applications that are coming along now, that we hear a lot more about.

D. Bartholomew: Would you comment on the hermetically sealed controversy that is going on with some of the packaged meat products, because you did bring up that there is transfer. It's puzzling to me why they would transfer that to hermetically sealed terminology.

Hotchkiss: Let me make sure I understand your question. You're asking why the regulatory agencies are transferring what they've traditionally applied in the canning process to fresh or hermetically sealed products? Well, they do that because the first concern of all regulatory agencies is with anaerobic pathogens, virtually always *Clostridium botulinum.* When you take a product that will support *Clostridium botulinum* and seal it in a package that may, either because of it's specifically been removed or because of metabolism in the product, not contain oxygen, then they consider that an undue hazard and have strictly forbidden that at the retail and the restaurant levels and strongly discouraged it from the manafucturer. The words used by FDA for this are such beautiful regulatory words. I know the guy at FDA, Tom Schwartz, who wrote these words. I called him up and asked and he said it's "fraught with danger." That's the FDA terminology. And I said, "Tom, where'd you get this." He said, "We went downstairs and drank a lot of coffee before we came up with that." They *are* concerned and I have a little bit of sympathy for them; and I have some sympathy for the people that want to do this, too. You can almost divide people up who want to do this. I mentioned Culinary Brands in California, who wants to do sous vide, which is the same thing — it's a hermetically-sealed package which is not total lethality processed. They have done a tremendous amount of work. They have the lifelines code system from Allied Chemical on it. They have shown that it cannot be scanned if unsafe, because the code will go bad before the product becomes toxic. They've done a really first class job of establishing their process. On the other hand, there's "mom-and-pop" food processing or a restaurant down the road who really doesn't understand all these nuances. So FDA, and in New York State, the Ag in Markets, kind of regulates to the lowest common denominator and they've said anything hermetically sealed falls under those regulations. It turns out that for retail establishments, there's a regulation that has been on the books for a long time that says that retail establishments can't do this; and the reason that it's there is that some years back, some retail establishments wanted to do in-house canning. What they're really doing is shirttailing on a regulation that was set some 12 or 15 years ago to prevent canning from being done in the stores. So they just adopted the same language, I think.

Bartholomew: How would you define hermetically sealed?

Hotchkiss: I'd define hermetically sealed as sealed against the transfer of moisture or moisture vapor, although you're going to tell me that the moisture vapor permeates or penetrates through, and it does, but that's the definition. Actually, they have wrestled a bit recently with the definition. It's causing all kinds of problems because "is a grocery store that does this food process a food processing establishment or is it a grocery store?" — or "is a restaurant that does this process a food processing establishment or is it a restaurant?"

M. Dikeman: At the beginning of your presentation, you talked about meat as being one of the areas in a retail store

where we'd have to do further processing to make that product ready for the consumer. You also talked a little bit about Excel's vacuum-packaged retail-ready products and some of the problems that they're having. After sitting in here this afternoon, I'm asking "Where do you see the future going in the way of retail ready products?" I assume that we're not quite there yet; and if not, what kind of new information, new research data, and so on do we need before we can make that transition to making that a more common processing system - retail-ready made by the packer/processor?

Hotchkiss: The technology of modified-atmosphere packaging red meats is here and sufficiently advanced. By that I mean: The packaging companies that make materials have developed materials that work very fine; the equipment can be bought off the shelf; the shelf life is there, it can be done; and the central packing is developed and can be done very nicely. In other words, other than some issues about safety, I don't think it's a research problem. In fact, we're actually phasing it out of my own research program, except for a little bit of work on safety. So, the technology's there. There are, as I've alluded to, a lot of social and economic problems that crop up in the system. I mentioned one, at least I've been told, that union resistance is a problem. The meat unions don't like it, and you can see why. There is some resistance by consumers who wonder why you have that partially empty package. They want to know about that kind of thing. There certainly has been a lot of resistance to vacuum packaging, because, frankly, the meat industry educated the consumer for 30 years about the bloom in meat and now all of a sudden you're saying we weren't quite right then, but it's OK if it's not bright red. You're changing the tune and it's hard to change direction with the consumer. I think there's going to be a resistance, at least some resistance, because of the solid waste problem which appears to be a problem in Ontario, Canada, where you see all the recycle bins around this university, just like it is in the States. But none of those are technical or scientific issues, at least directly, in my opinion. Which way it goes, I don't know. On the one hand there is, I think, very strong and very important economic and processing reasons for, particularly, the red meat industry. I mean Frank Perdue is doing "retail-ready" in the store and you know where chicken consumption is going. He's advertising it and selling it for a dime more a pound because of this technology. In most of his markets, because he can brand it and get on TV and tell people it's better, he can sell chicken for a dime more a pound. So, there are some strong economic incentives to do that and to do other things in that space in the grocery store like sell blue jeans or something important. On the other hand, I think there are social and economic barriers to the system and I really have no prediction, I really can't say. Some of you may have better guesses or Deane may have a better guess on which way it's going to go. It works, but there are problems.

Galloway: I don't know if I have a better guess. I guess anybody's guess is as good as anybody else's. I think that some of it is economic and part of that is the recapitalization of the industry needed for retail-ready. That's one issue. Certainly Excel's doing retail-ready and other people have done it. We've been involved in it, but there's a lot of equipment that would have to be put in place to do it on a major scale and that's an issue. There's no question about that. Excel's done it on a small scale, but to do it on a nationwide basis will require a lot bigger recapitalization. Unless everybody's sure it's going to go, it's one of those old ballgames. They're not willing to put that kind of money up front, I think. Plus, some of the packers, I think, have some concerns about handling the number of cuts that would be involved to do it at the packer's level, which I think is the most economical place to do it, versus handling the smaller number of primals that they offer now. They'd have 10 or 20 times as many retail cuts to inventory, distribute and manage, etc. So, there's that kind of resistance. So, what's going to happen, I don't know. I guess my personal feeling is, I think it will happen at some point, but I'm not sure when that's going to be.

Dikeman: Is one system safer than the other — vacuum versus modified atmosphere?

Hotchkiss: It depends on how you do it. I like modified atmosphere better. I don't care what you're putting in the package, I say don't make it anaerobic, put some oxygen in. We have some very good data in cooked roast beef, for example, that shows that as little as 2% oxygen substantially inhibits *Clostridia*. It cuts down a little bit on shelf life, but we've published data that clearly show that it creates a whole different ballgame. I like modified atmosphere simply because you can get a little bit of oxygen in the system and I think that is, for safety's sake, a very good thing. Maybe it's not as big a concern in raw meat, for example, which is always cooked, but even so, I just like a little bit of oxygen inside a package and you can't do that with vacuum-packed. Vacuum-packed is not a problem. They have been around for a long time and we've got a good history, but also, most of the vacuum-packaged meat has not been in the hands of the consumer. Most vacuum-packaged meat has been in the hands of the distribution people. When you put it in the hands of the consumer, you may escalate the problem with it.

Marchello: What about *Listeria?* It's been a hot issue on the forefront. How does it play a role in this safety issue?

Hotchkiss: Well, we specifically, in the work I showed you, picked on *Listeria* because *Listeria* is an organism, which the literature would suggest, that is actually enhanced by reduced oxygen content, but does not grow anaerobically. *Listeria* is a case where we think, as the data showed, that the pathogen will proliferate very rapidly, while the spoilage organisms which would warn people not to eat things, would not. If you judge the safety of food products on whether or not they will support pathogens, you would never sell ground beef. If you put anaerobic pathogens on the surface of ground beef, they grow like crazy. If you inoculate anaerobes into the center and temperature-abuse it, they grow like crazy. What keeps ground beef from being dangerous? Well, probably the biggest thing that keeps ground beef from being dangerous is it also spoils like crazy. You know, it changes, it gets slimy, it "walks around the table." It's a very perishable product. Now, ask yourself about ground beef. If I take away that color change and I take away the slime and the odor, none of which have anything to do with its safety, you can eat the slimy, stinky ground beef, probably raw, as long as I know of no specific pathogens in there. If I take that away and I leave behind the pathogens, then I may have changed the picture and it turns out that I've been challenged. Is there such a case? And now we have data. Yes, there is such a

case with *Listeria.*

D. Buege: Joe mentioned solid waste management as one of the possible social issues and I know that in Wisconsin a committee of the legislature is looking at a bill that would ban all multilayer films by 1991. How big an issue do you think this will become and how do you think the packaging industry is going to deal with this?

Hotchkiss: I like questions where you can say something about the packaging industry. I think that it will be a major issue of tremendous significance all across the United States. I'll tell you why. The EPA has done some very good work in studying this issue. In the U.S., by 1995, which is right around the corner for us, one-half of our landfills will close — one-half. Now I don't know if anybody's tried to open a landfill where you live, but it is impossible to open a landfill — it's a thing called NIMBY (not in my backyard). So, we're losing all of these and the cost or the "tipping fees" for waste disposal are just going up and up and up. They probably are going to increase 1000% by the turn of the century — that's my prediction. You will see ads in the paper that say "two bedroom ranch, natural gas $60 a month, electricity $80 a month, waste disposal $90 a month", something like that. It's going to be a major utility cost for owning a home, for example, because all of the acceptable technologies for dealing with the problem are expensive. So, it's going to be a very big problem.

What's happening right now is that the person on the street is blaming the packaging industry even though there are some strange things like 17% of the solid waste stream is yard waste. We all throw away our grass clippings and things. Plastics are 7%; yard waste is almost two and half times what plastic waste is. So, the public doesn't have the right perspective of what is really going on. So, what do they do? They do what we're so proud of in New York. They pass strange legislation and it's always geared to packaging, and you're going to see more of that.

Anybody here from Minneapolis? Minneapolis has the only municipal legislation. They essentially empowered one person, some guy — a head of a commission or something. You bring your package in; he looks at it and says this is environmentally unacceptable, pffft. You can't sell in the city of Minneapolis. I don't know how many cities the size of Minneapolis there are, so if you're in the packaging business, you're in serious trouble. The packaging industry's response is just what you'd expect it to be. They're very worried about it. They're on a massive education campaign. They are pouring huge amounts of money into trying to get the consumer, the voter really, to understand what the problem is. They're trying very quickly to come up to speed in recycling some of these products. Ask Deane, I'm sure he'll tell you that his company thinks that this is a serious problem and they're addressing the issue and doing things about it.

Galloway: Yes, that's exactly right. We could spend an awful lot of time this afternoon talking about that particular topic. We have people working full time on it. Of course, you're aware, Dennis, of what's gone on in Wisconsin. We've had people presenting our position to subcommittees from the Wisconsin Legislature. There is a lot of misinformation and Joe alluded to a lot of that. Paper and yard waste make up a huge part of that waste stream, almost two-thirds of it, while plastics, as Joe said, is about 7%. Also, the concept of biodegradability is very much misunderstood. A lot of the things that you would assume biogdegrade in landfills do not. Vegetable products like carrots still look like carrots after 10 years. And in fact, a lot of people take the position that they don't want landfill contents, plastic in particular, to biodegrade because then you've got a potential for seepage and water contamination from them.

Yes, there is a lot of misinformation out there and we're trying to do our best to educate, but in the meantime a lot of legislation is being passed that is making it very difficult to operate. We could go on and on talking about that, but that wasn't the primary purpose of the session this afternoon, and we have come to the end of our time. I want to thank Joe for both the presentations this afternoon. I think he did an excellent job and we're glad we could sway a non-AMSA member to share some of his thoughts with us. Thanks, Joe, very much.