

Management Practices and Meat Quality  
Michael Ellis

[1]All right. Well, we'll go ahead and get started here. It's my pleasure to introduce to you Dr. Mike Ellis. As you'll notice, when he starts talking, it's not the microphone that sounds strange. It's him. He is a faculty member here at the University of Illinois. He was born and raised in the County of Northumberland in the north of England, and he received his BS and Ph degrees from the University of New Castle in England, and since 1992, we've had the privilege of having him on the faculty here. He is a Professor in the Animal Sciences, and he is going to be discussing management practices and pork quality this afternoon. Thank you. Thank you John for those few kind words. This is the way that English is meant to be spoken. I have to say it. So, I make no apology for sounding strange. It's an accent that took a long time and cost a lot of money to develop and one I'm very proud of. So, it does mean that very few people here understand a word that I'm talking about, and also, I'm in a position where I don't know what the hell I'm doing here to be honest. I know why I'm here, but I don't know what I'm doing here. I blame the good Dr. McKeith who has spent a lot of time since I arrived at Illinois trying to put me in embarrassing situations or what they call in the north of England dropping me in the cloths, which I'll let you use your own imagination to understand what that means, and he originally suggested that I give a presentation on management practices and pork quality. What he didn't tell me was that it was in a session on biotechnology, and anybody that knows me knows I can't even spell biotechnology, and I'm quite happy because of that. So, I'm not so sure how or why this fits in with the previous very high-quality, high-powered presentation, but if you're concerned or you're not happy about what you get, please blame Dr. McKeith. Let me first acknowledge Matt Ritter who is in the audience. Most of what I'm going to talk about today relates to work that Matt has carried out.

[2]The areas I want to try and focus on is to talk a little bit about what is management, what is pork quality, and what is the link between them, and I'll spend a little bit of time talking about transport losses, because in terms of the research that my lab has been involved with and particularly Matt Ritter has been involved with it has been looking at management factors and transport losses, and I think there's a link there also into pork quality.

[3]My official title is Professor of Swine Management, and so, I thought I understood what management was, but I thought that I also better go and look at a dictionary to make sure that I could explain it to you in succinct terms, and here's the definition that I came up: The organization and control of the way something operates. It's a pretty broad and vague definition. So, the organizers were very generous to me. They've given me a lot of leeway, and I can talk pretty much about anything that relates to pigs and the process of getting from conception to consumption. By that definition, it all applies. I'm going to take a fairly narrow focus, a very narrow definition of management and focus on pre-harvest animal handling as my definition of what management is.

[4]I just want to be sure that you understand or appreciate the definition that I'm using when I talk about pre-slaughter animal handling or pre-slaughter pig handling, and in the narrowest form of that definition, we think of pig handling as the process of actually moving pigs at the farm, to the trailer, off the trailer, through the plant to the point of harvest. I'm going to take a broader definition that encompasses pretty much anything and everything that could happen to an animal from the farm pen as it's moved through the building, onto the transport, to the plant, and after transport, into the plant. Actually, this could include quite a lot of things that happen long before we even ship that animal from the farm to the slaughter plant. So, I'm going to talk about a lot of things in relation to management of that animal around the time of transportation.

[5]What is pork quality? There's an audience here that knows a hell of a lot more than I do about it. I'm going to take, again, a very simple definition. Certainly, quality is a very complex multi-faceted concept. Again, there are various attempts to define quality in its broadest sense, many, many different components. I'm going

to focus mainly on color and water-holding capacity and on the issues in relation to color and water-holding capacity of PSE and also of DFD. Those are two meat quality defects that we deal with in many situations.

[6]Is there a link between handling and pork quality and what is it? Well, I think there obviously is a link. It's mediated through the processes that we take an animal through from the farm through to the point of harvest that result in stress on that animal and also increase activity levels of the animal, and again, this audience doesn't need to be reminded of this, but stress and activity levels have a fairly significant affect on muscle metabolism, both pre and post-harvest, the influence of muscle energy levels and the influence of muscle temperature, and it's through those three particular mechanisms, if I can call them that, that we see changes in the muscle postmortem, changes in muscle pH, and temperature in particular and the associated changes in muscle color and water-holding capacity. So, I think that's the link between how we handle pigs pre-harvest, if you like, and quality.

[7]A key issue in terms of what is happening at this particular stage or key issues are the intensity and the timing of the pre-slaughter stress and the pre-slaughter activity, and again, it's fairly clearly defined in a number of texts that we can distinguish two basic types of stress that can affect quality. One is what is sometimes referred to as short-term acute stress, which occurred when it occurs very close to harvest, and it influences the incidence of PSE through it's affect on postmortem glycolysis and also on muscle temperature. The second type of stress if you like or definition of stress, a chronic stress, which by definition is much longer term, and I think in terms of the time period that we are interested in, in the..., in relation to pork quality, it's probably the last twenty-four hours before harvest, and it influences the level of DFD that we experience via an affect on muscle glycogen levels at harvest. Sometimes, we consider that this sort of stress is very intense, a relatively high level of stress, and the more chronic stress is perhaps a lower level of stress but one that goes on for a longer period of time, but actually, in fact, I think we can have the same levels of stress in either situation. It's just the timing of when they occur that has the important impact on quality. For example, animal handling; if we aggressively handle animals just before slaughter, we will increase the incidence of PSE. If we aggressively handle animals during the process of loading at the farm and unloading at the plant before they are rested prior to slaughter, then we'll tend to have an influence on the incidence of DFD.

[8]I'm going to switch gears a little bit and try and bring the two different themes that I'm going to talk about together a little bit later in the presentation. I'm going to talk a little bit about transport losses, because as I said, that has been the area that we've been focusing on and certainly Matt Ritter has been focusing on in the last couple of years and where I'd like to share some of the research results we've found in this area. I'm going to give you some definitions of what we consider to be losses, and the work that I'm going to relate to you relates or considers or has examined transport losses up until the point at which the animals go over the scale. Certainly, there are losses within the slaughter plant that may also be related to transportation, but we've drawn the line, if you like, in our definition of transport losses at the stage at which the pig actually goes over the weigh scale and goes into the plant, and there are two basic types of losses that we have defined. One is dead on arrival at the plant on the truck, and then, the other category is what we would call non-ambulatory animals; animals that either can't move or can't move at a sufficient speed to keep up with the rest of the animals on that particular load of pigs, and in terms of non-ambulatory animals, there are two types that we've defined. One is non-ambulatory because it has some obvious form of injury, and then, the other one is what is sometimes called the NANI animal or non-ambulatory non-injured pig that has no obvious physical injury but does not move or does not move at a speed to keep up with the rest of the group. In practice, these are referred to by various terms such as slows, subjects, suspects, or downers. The politically correct definition or term that is commonly used today is that these are fatigued pigs, and we focused most of our research efforts trying to understand the causes and the factors that lead to an increase in the incidence

of fatigued pigs, and in many situations in the field that we've looked at, we see that the biggest cause of loss or the biggest type of loss is in these fatigued animals. So, they are a significant source of loss to the industry as well as being of a significant concern from an animal welfare perspective.

[9]These are just some numbers that I think many people here have seen about the incidence of dead pigs on arrival at packing plants going from 1990 through to 2004, and what we've seen is an increase in incidence in the early to mid 90s up to a level of about point three percent of all animals delivered to slaughter plants in the U.S. would be dead on arrival, and we've seen some reduction in incidence over the last three or four years, I think, with an increased awareness of this problem and an increased awareness of some of the factors that we can change to try and reduce the incidence. Nevertheless, we are still today dealing with an incidence that's probably about three times higher than it was ten to fifteen years ago.

[10]we really don't know, on a national basis, how many pigs arrive at the plant non-ambulatory or fatigued. In field studies, we've seen incidences ranging from as low as point two percent to as high as one percent. So, we would guess that, on average, the range of sort of transport losses, including non-ambulatory animals and dead animals, would be somewhere in the range of point five percent perhaps to as high as one point three percent. So, quite a significant proportion of our pigs that leave the farm in good condition don't arrive in good condition at the plant; significant economic loss, significant welfare concern.

[11]The fatigued pig syndrome, if you've seen the photograph, there are some very characteristic symptoms. These pigs generally show open-mouth breathing. They are generally showing..., skin discoloration. It's very difficult to see in this slide, but that has blotchy red patches across the skin. Muscle tremors are a common symptom, and unresponsiveness to stimuli to move. They will also show a very characteristic vocalization. Once you've heard it, it's not easy to mistake again; characteristic vocalization. In other words, these pigs show what we would characterize as a characteristic; extreme stress response. So, I think the link between quality and transport loss is certainly, in relation to these fatigued pigs, one through the root of the stress that the pigs experience during the transportation process.

[12]If we look at metabolic changes in fatigued pigs, a lot of this work was done initially by Dave Anderson at Elanco. A lot of the metabolic changes, we've looked at blood parameters and blood acid-based stages using this very simple human medical technology that gives you an instantaneous readout of blood acid-based stages. Dave Anderson looked at fatigued pigs and normal pigs within slaughter plants in the U.S. and saw the characteristic change in the blood acid-based chemistry, increase in blood lactate, decrease in blood pH, and also a very significant elevation in body temperature, and so, these animals are exhibiting extreme metabolic acidosis and also a very significant increase in elevated body temperature. We would see, characteristically, increases in body temperature of four to five degrees Fahrenheit in animals that were showing the fatigued condition. Interestingly, in our animal handling models where we've handled pigs very aggressively to try and create the fatigued pig syndrome, in animals that were handled aggressively, we've been able to produce almost identical metabolic changes to those exhibited by the fatigued pigs at the slaughter plant.

[13]we think there is an accumulation of stress or stressors acting on these animals. If we start off with a normal animal that is exposed to some degree of stress, you start initially to see some open-mouthed breathings, some skin discoloration, some refusal to move. If we continue with the stress on that animal, we start to see the abnormal vocalization, muscle tremors, and then, the animal goes down and would be defined as fatigued. We would also define this animal as a fatigued animal if it refused to move. If we continue with that stress, then, ultimately, the pig will die, and we think there is a relationship between deaths in transport and also the incidence of fatigued animals at the end of transportation.

[14]Some interesting observations - well, some observations that we made, whether

they are interesting or not is up to you to tell, but basically, we've seen fatigued pigs at any stage from the animal leaving the pen to arriving in the slaughter plant. They occur very, very commonly at the farm. It's not just the phenomenon of transportation. In my opinion, most of the pigs, if not all of the pigs that we've dealt with under commercial conditions will become fatigued if we subject them to sufficient stress. We have some thoughts that some of the stresses may be additive.

We can certainly create a fatigued pig with one extreme stress such as very aggressive handling, but we also think that more moderate stress, if there is enough of it that accumulates, can lead to the fatigued pig syndrome, and the other thing that we've seen is that the majority of fatigued pigs will recover, if we give them sufficient time in a minimum stress environment. Probably above seventy-five percent of pigs that we've seen in that situation, when we've put them in a quiet area by themselves, have fully recovered.

[15]So, what's the link between transport losses and pork quality?

[16]Well, Dr. McKeith and some of his students went into slaughter plants in the Mid West. Actually, they went into four slaughter plants and looked at several hundred fatigued animals, followed them from the point of slaughter through to the overall meat quality, and here are the results for the individual plants, and here is the overall mean for those four plants. We have an ultimate pH of six, subjective color score on the end of a PPC six-point scale of about four, Minolta L\* of forty-six, drip loss by the suspension method of less than two percent. Those sorts of measures would define the meat as certainly - a significant proportion of the meat is DFD or approaching the DFD condition. So, these fatigued animals, on the average, exhibit DFD, which suggests very strongly that they have reduced muscle glycogen levels at the point of which they become fatigued, and so, I think there is a link between the two conditions through that particular route.

[17]What I wanted to talk about for most of the rest of the presentation were some of the factors that we've looked at in the handling of animals from the farm pen through to the point of arrival at the slaughter plant that are likely to increase the incidence of transport losses and are likely to be involved certainly in determining the incidence of DFD in animals. We've looked at the farm level and looked at various aspects of facility design. There are certain facilities that are designed where it's very difficult, because of the design, to handle animals without stressing them. We have some buildings in our industry with very narrow aisles where it's very difficult to handle pigs without stressing those animals. We have some very long buildings, and I'm going to talk a little bit about building length in a minute. We have some ramps for loading the pigs that are inappropriately designed. The temperature and humidity, obviously, are other potential stressors on the animal at the farm. Handling intensity at the farm; as I've said previously, handling intensity certainly increases the stress level and can increase the incidence of downers and then, some of the management approaches to try and sort animals prior to loading that could, in theory, reduce the stress on the pig.

[18]I'm going to just talk a little bit about some of the studies we've done, mainly in Illinois, to try and understand how much these factors are involved in determining transport losses. This is a typical Illinois swine building; wean to finish facility. They are about one hundred meters long. I'm always amazed, and I say this at every presentation, that I came to the U.S. in 1992. If anybody had told me then that I'd be working in buildings within which you could run the Olympic hundred meters, I wouldn't have believed them, but all of our buildings, or the vast majority now, you could run the Olympic hundred meters inside. Invariably, they are allowed out at one end of the facility, and so, the pigs at the far end of the facility, literally, have to do the hundred meters before they get on the top of that truck. That wean to finish facility; they go in at three weeks of age, and we go back six months later and try to get them out of those pens and onto the back of the truck with minimal stress, and I think we are being somewhat naïve. I've used these slides before, but if these pigs were trained like Olympic sprinters, we would probably see very little metabolic response, but if we add this guy, we actually see quite a big metabolic response. This is about the fifth time I've used this slide, and every time, he finds an excuse not to be in the audience when I use it, but this

was McKeith before he got tenure. I think that's the best we can say. Sorry. Cheap shot but it's not worse than biotechnology and management and meat quality.

[19]Matt Ritter did a study where he looked at the distance that pigs are moved at the farm, short being zero to thirty meters from the door, long being sixty to ninety meters. So, basically, at either end of one of those wean to finish buildings, there are one hundred and nine loads of pigs, about seventeen thousand animals involved. Now, what we saw was an increase in the incidence of non-ambulatory pigs, fatigued pigs at the farm. The pre-value here is point zero nine. I'm going to do something today that I try - try - that I insist my graduate students don't do. I'm going to present you results where there are some what I consider to be big differences in transport losses but where the pre-value is nowhere near point zero five. So, I'd probably get stoned in a scientific meeting like this. Let me just give you the reason why I'm going to do that, and let me just say up front that what I'm trying to do when I present this information is not present you with fact but to suggest some areas where we might look a little bit more closely. Most of the studies that I'm going to present you, Matt Ritter went out with a group of graduate students, and occasionally, about once in every fifty visits, I went with them, at about midnight and actually loaded pigs and followed these pigs through to the slaughter plant, and the reason we did that, and unloaded them at the plant, the reason we did that was that in our early studies we found a big affect of driver of the load on how those pigs were handled. Some drivers handled them well, some not so well, some aggressively, some less aggressively, and so, we decided that we would use the same crew to load pigs and unload pigs for all of our studies, and that was Matt and a group of graduate students. Whenever we've gone out and done that compared to what we observed in that particular system before we did the study, we have at least half of the transport losses, and in some situations, we reduced them to a third of what they were. Now, I'm not arguing that we know anything better than anybody else about handling pigs, but we are now dealing with a situation where we were dealing with... transport losses in systems of one percent or more, and in our studies, they are about point three to point four percent, and it's very difficult to get statistical significance when you are dealing with such a low incidence, particularly when it's a sporadic incidence. So, I make no apology for using results that don't have - that aren't less than P equals the point zero five, but I think there are some important trends there that somebody needs to do some bigger studies, perhaps under more commercial conditions, to validate what our results suggest, but certainly, the further we move pigs at the farm, the much higher incidence of non-ambulatory pigs on the back of the truck after loading. P equals point zero nine. We looked at losses at the plant. There was no affect on beds. There was no affect on fatigued pigs, but there was an affect on non-ambulatory injured pigs at the plant. Here we have P is point zero six, but the short distance, non-ambulatory injured pigs at the plant was less than point zero five. The long distance moved somewhere up near point two five. So again, perhaps just a suggestion that what happens to the pig at the point of loading or before the point of loading can influence the stress level on that animal, can influence injuries, and can influence transport losses.

[20]We've looked at the fasting of pigs prior to transportation. Here's one study that Matt carried out where we looked at twenty-four hours versus hours on feed - of feed, sorry, and if you look at total transport losses where they were kept on feed up to the point of transport, point three six percent, where they were off feed, somewhere in the order of point one eight percent; so, about halving of transport losses. Nowhere near statistical significance, but a significantly large affect that I think it's something that we should look at further.

[21]In terms of transport, which is increasingly where we spend our time trying to understand what's happening to the pigs during transport, this is a black box, and it's meant to be a black box, because I think in terms of our industry, it is the big black box that we don't really understand what's happening, and I don't think we know what the association is between what happens on the truck and transport losses and pork quality. We've been trying to shed some light on the transport loss part of it by looking at certain aspects of the transportation process.

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[22]Here is a list of the things in transportation that, in theory, would affect the stress level the animal experiences and therefore affect transport losses. I've just highlighted in red here the three areas that we've spent some time trying to evaluate.

[23]we've looked at trailer design, basically straight decks versus pot decks. Certainly, a lot of people would suggest that perhaps it's more difficult to handle pigs on potbelly trailers, and therefore, the stress level may be higher there, and we might anticipate more problems. We looked at a range of different aspects including the time for various activities. One of the things we showed was that it was much quicker to unload a straight deck trailer than a pot deck trailer, because in the pot deck, there are a lot of internal ruts that you have to drive pigs up and down, and that just takes a lot more time. These two trailer designs actually hauled about the same number of pigs. It's not that there are more pigs on the potbelly. It's just that it takes more time to get them up and down those ruts. We looked at physical indicators of stress that we talked about, particularly open-mouth breathing. Our open-mouth breathing was where we saw the differences. We found that the potbelly in spring and summer gave us a higher incidence of physical indicators of stress, but when we looked in the fall and the winter, there was no affect of trailer design, and when we looked overall, surprisingly perhaps to a lot of people, we showed very little difference in transport losses between the two trailer types. Again, these were loaded and unloaded by the same crew from the University of Illinois.

[24]we looked at things like mixing of pigs on the trailer. Here is a study where we looked at pigs coming from the same home group, unmixed versus mixed. If we look at the total transport losses in red here, where we mixed the pigs on the trailer, we are up at about point three seven, point three eight percent total loss, where we don't mix them, we are down to about point one eight. The P value, again, is point three; so, not statistically significant, but again, relatively speaking, a huge difference that's well worth, I think, studying further under commercial conditions.

[25]We spent a lot time, a lot of time, probably three or four studies now, looking at floor space on the trailer. I'm just going to very briefly touch on that work. I just put this slide up to give you some idea of the ranges we've looked at. The minimum we've looked at is about four point two square feet per pig, and the maximum we've looked at is about five point eight square feet per pig. You can get some sense by these black areas here how tightly packed those animals are. Here, there is very little space visible here. At the higher floor space, you can see quite a lot of space that's visible.

[26]Busy slide; this is a study where we looked at the range from four point three to five point six square feet per pig, and we looked at losses, the various types of losses, and then the total losses are in blue. So, if we look at total losses in blue, what we saw was that as we increased floor space we reduced total losses down to a minimum that, in this example, is about five point three square feet, and there are some suggesting that they may have come back up, and actually, we do have statistical significance on this graph. These three higher floor spaces are significantly lower than the three lower floor spaces. So, it suggests that there is a big affect of floor space on transport losses. We are going from three percent here at the tightest level down to zero or close to zero in the best results that we got. Just to put that into perspective, these were two hundred and eighty-eight pound pigs. The National Institute of Animal Agriculture that has produced recommendations on floor space that, as far as I'm aware of, are the only ones that are published in the public domain out there and suggest that with this size of pig we should be somewhere around about four point five five, four point six square feet per pig. That's not going to minimize transport losses based on this data.

[27]I had a nice video to show you, but unfortunately, it hasn't moved over onto this computer. So, you'll have to use your imagination. We also looked at the behavior. This is a video camera above the compartment, and so, we've got video footage on these animals at these different floor spaces, and this is the floor space of about four point three square feet, and it's perhaps difficult to see, but

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these animals are standing. One of the interesting findings of that work was that animals, this was on a three-hour journey, the animals stood for virtually all of the time during that journey. That was not what we expected, not what I expected. Perhaps it would have been what you expected, but I've only observed pigs at the farm where during loading and the... are standing and then will lie down if they're settled down, and then, I've observed them when they've arrived at the plant, and shortly after delivery, if you go and look in the truck, they are pretty much all lying down. So, we expected them to lie down for part of the journey. They didn't. They stood for most of that journey. This animal here was actually sitting. When you've got animals as tight as this, if an animal sits or lies down, they are the ones that are likely to come off that trailer dead. They aren't going to get up, if they go down in this sort of density of animals on the truck.

[28]If you to the other extreme at the five point eight or five point six square feet, you've got a lot of there, and that's not good either, in my opinion. If you saw the video of those animals, they get thrown about that compartment all of the time, and although we have not picked up any difference in injuries in animals at different stocking densities, during the video recording part of it, I think you are going to see more stress on those pigs and more injuries as a result of being thrown around that particular trailer. So, there is an optimum stocking density. You can certainly have them at too tight the floor space, and you are going to have higher losses, but you can give them too much space, and I think you are also going to potentially have higher losses and higher injuries in those particular animals.

[29]It's not as simple - nothing in life is as simple as you first think, but when we've looked at the effect of floor space, what we've seen in some studies, and here's an example here, is that we get some interaction between floor space and season, in this particular situation. So, here we have a study where we looked at three floor spaces; four point two, five, and five point eight square feet, and we looked at it in replicates carried out in the spring and also in the summer. In the spring - and these are total losses. In the spring, absolutely no affect of floor space on transport losses. In the summer, it was the big effect that we saw in the previous graph, and so, there is going to be an interaction between the floor space and the climatic environment and possibly other factors that is going to influence what is the optimum floor space for animals in that particular situation and what effect that floor space actually has on the animal.

[30]Just perhaps to give some insight into why we might see some of those factors, here is just some - one slide of some changes in relative humidity on a truck. During the winter months - this is actually a January load, the 1st of January in '04 where the temperature was something like minus ten when they actually loaded these pigs, and this looks at the relative humidity on the top deck and the bottom deck, and as you can see, relative humidity is lower when they first start loading, and it increases very dramatically to relatively high levels. It's higher on the top deck than on the bottom deck, and then, it comes down a little bit, stays relatively stable during the journey, and then, when they stop at the plant, the humidity shoots up, and it doesn't start to come down again until they start to unload that particular truck. The only reason that I put that up is to show you an example of some fairly extreme changes in the conditions on the truck and some differences between the top and the bottom deck, and I think a lot of the impact of what is happening in transportation is obviously going to be determined by the micro climate that those animals are experiencing on the truck, and frankly, I don't think we've real idea what that micro environment is. We've just started a study funded by the Pork Board to try and put sensors in the livestock in a flood deck pig transporter to try to get a detailed pattern in the different weather conditions; just exactly what is happening on the trailer. I think we'll get some insight into the sorts of extremes that pigs are probably being exposed to in various weather conditions.

[31]Okay. I'll try and pull it together. What can we conclude? Certainly, you can conclude that this isn't biotechnology and that pigs do experience a wide range of potential stressors from the farm through to the point of harvest that is going to influence losses, and I think this is also going to influence pork color and

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water-holding capacity. Our knowledge of the impact of many of these management factors is extremely limited. So, although we've shown some associations between transportation factors and transport losses, I'm not aware of much work in the U.S., under our conditions, that... the delinquency in those factors in pork quality. Certainly, there has been an attempt to do some of that in Europe. Most of it is in Western Europe where they have a temperate climate and don't have to deal with the conditions that we have to deal with certainly in this part of the world. So, I think there's a need for significant research in this area.

[32]I'm going to leave you with an acknowledgment. This work is being funded by the National Pork Board and Elanco Animal Health. We've had the cooperation of the Maschhoff System in access to facilities, trucks, and pigs, and we've had considerable help from Cargill Meat Solutions through their... plant to help us collect some of this data.

[33]And I'll end just with a photograph of a happy pig in the Dominican Republic that also knows nothing more than I do about biotechnology. Thank you very much for your kind attention.