S4P05.WP

TRANSCUTAN, LOCAL, ELECTRICAL STIMULATION, A METHOD FOR IDENTIFICATION OF NON-DFD BEEF CARCASSES

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INTRODUCTION

Good knowledge about meat raw material quality is very important for successful meat processing. When vacuum-packing primal meat cuts, it is crucial to avoid packing of DFD-meat having an ultimate-pH-value higher than 5.9. It is difficult to understand why there are no official regulations for the ultimate pH-value of meat given the significance of pH-value upon the shelf-life of meat. At the time of boning, and especially when carrying out pre-rigor boning, it is vital to determine if the meat carcasses originate from long time stressed animals which are producing DFD meat (dark, firm, dry) having a pH-value higher than 5.9.

In normal, unstimulated muscle the ultimate-pH-value may not be reached until 40 hours post-mortem. In stimulated carcasses the ultimate pH-value is normally reached 16 to 18 hours post-mortem. This means it is necessary to keep carcasses, in many cases, in an expensive cooler for between 18 and 40 hours until it is known if the carcasses are DFD or not. A method for determining the ultimate-pH-value of meat by two hours post-mortem has been said to be very desirable, (Hofmann, 1980; Buchter, 1982; Purchas, 1988).

In addition to laboratory methods using biochemical intermediates from post-mortem, glycolysis, energy metabolism, several destructive methods based on enhanced post-mortem glycolysis combined with subsequent pH-drop measurements for early DFD detection are described in the literature. One is based upon addition of Ca- and Mg-ions (Vada-Kovács, 1981). Another, from New Zealand, is based upon liquid Nitrogen freezing and thawing (Davey and Graafhuis, 1980).

The pH-value of a DFD carcass, achieving an ultimate-pH-value of for instance 5.9, will not at any time decrease below 5.9 if stimulation is carried out according to the method described below (Honikel, 1984). This basic fact, upon which this method was developed, provides a simple non-destructive test for early detection of non-DFD meat.

Method for local electrical stimulation

This method was first developed in 1984, the "original model" was based on local electrical stimulation of the *longissimus lumborum* muscle using a stimulation apparatus, in which the electronic part had a special built-in insulation system. It was equipped with two specially designed 10cm long electrodes in a polyethylene handle. Using this apparatus immediately after dehiding allowed the electrodes to conduct the stimulating voltage into the deeper parts of the *longissimus* muscle section. The two electrodes are placed 10cm apart. The operators do not feel any irritating voltage when working on the carcasses as a special electronic control circuit, not present in other electrical stimulators, is applied.

More recently the above method has been refuted and a "new model" has been designed. It is now based upon transcutan electrical stimulation using two brass electrodes which are pressed against the skin by pneumatic pressure. This model allows the local stimulation to take place before dehiding after debleeding is completed. An electronic control system is used to make the stimulation process semiautomatic and it is carried out two minutes post-mortem for 90 seconds. Following the above procedure the pH-value is measured at the end of the slaughter line, 20 minutes post-mortem, by trained personnel where grading and weighing is carried out.

The absence of needles makes the process easier to automate and much more hygienic. The new model also takes advantage that the pH-value of the stimulated muscle section falls very rapidly, because the voltage "over" the sections relatively high. When the carcasses pass the weighing scales on the slaughter line, the pH-values in the stimulated *longissimus lumborum* muscle, which do not develop DFD-meat quality characteristics, have fallen below 5.9, the "limit" presently used in Norway for sorting out DFD-carcasses.

Using one of these non-destructive methods, it is now possible to identify within 20 minutes post-mortem, (40 minutes when using the original model) that a carcass will not develop DFD. Longer local stimulation periods have been found to produce an even faster and greater drop in pH-value. However, this has the disadvantage in that PSE meat may develop in the local stimulated muscle section.

It must be emphasized that these two methods are used for finding normal and PSE carcasses and not for detecting DFD carcasses per se. For the latter purpose, these methods are not suitable. Some normal carcasses might not have been effectively locally stimulated and therefore may wrongly be classified as DFD. During operation, at the point where the carcasses are graded, the greatest part of the beef carcasses are classified as "Normal or PSE". These carcasses are then fed on one sorting rail. Another rail is for: "Suspected DFD carcasses" having pH-values higher than the actual ultimate-pH-value limit 5.9 presently used in Norway. This group of carcasses amounted in one plant to only about 3% of the total. This may seem to be a relatively low percentage, but management claims they are, from a quality point of view, extremely important to identify. To make sure that these carcasses (3%) are really DFD-carcasses, an additional local stimulation is carried out after they have passed the point of the slaughter line where the pH-values are routinely measured. After the second, local stimulation the pH-value is measured again.

Disadvantages

The incidence of PSE meat in beef is relatively high (Hamm, 1984), even if this is not often mentioned in the literature. Muscles stimulated by the above method for extended periods have been found to develop PSE. However, in practice, the duration of the stimulation has not developed PSE in the plant using this method.

It has to be mentioned that the two 10cm long non-sterile metal electrodes which are used in the original model, are stuck into the loin muscles. They are washed in a 82°C hot water shower before reuse. However, one type of equipment for grading pork carcasses have several measuring probes for penetrating the pig skin without giving hygienic problems (Galler *et al.*, 1987).

Due to the galvanic effect, also on the transcutan stimulator, the positive electrode has to be periodically brushed to remove corrosion and subsequently replaced. At the Danish Meat Research Institute the original model has been

scientifically tested. A special electrode composition very resistant to corrosion has been found. Discoloration also occurs in the area where the needle electrodes had been inserted. The explanation is unknown (Hald, 1993), although heat may have developed in the muscle. The users in Finland and other countries have not reported this discoloration under practical operation and it is absent when using the new model based upon transcutan stimulation.

Practical experiences

The original model, based upon needle electrodes was first described in detail in 1981. This model has been in practical semiautomatic operation at three plants in northern Europe since 1988 and is providing significant economic returns. The owners of one of these "combinats" have invested approximately 10-million U.S.dollars in a new wing at their plant (Laukkanen, 1989) of which this method is an essential part of operation. When using the old model, the two needle electrodes are manually "plugged" into the *longissimus lumborum* muscle by one operator at the dehiding machine as soon as the hide is removed and stimulated for two to four minutes depending upon the slaughter line speed. On the original model, electrode handles are fastened by a steel wire to a roundabout conveyor along part of the slaughter line. However the new model is located in the debleeding area and uses pneumatic pressure cylinders, one vertically and one horizontally mounted, which press the electrodes against the carcass loin prior to dehiding. An electronic control system using electromagnetic valves instantly washes the spots on the carcass loin and ensures good electric contact.

In one plant four meat graders carry out this quality sorting process using a portable pH-meter at the weighing station. They are also grading the carcasses and entering into the computer other quality parameters like: points for slaughter defects (like incisions in muscles, uneven splitting, surface dirt, unremoved kidney fat etc), the grade, animal owner, sex, carcass weight, trucker etc and the pH-value (Laukkanen, 1989).

The new model for transcutan stimulation has been in successful, daily use in a plant in Norway since the spring of 1992. Plant management tells it is a most useful piece of equipment as they hot bone their beef carcasses.

Pre-rigor boning: the process of the future

In one plant, the transcutan method makes it possible to carry out hot boning immediately after slaughter by a team of people who start their work one hour later in the morning than those on the slaughter floor. The use of the method makes it possible for the company to take advantage of no chilling weight loss of the whole carcasses, "nice and warm" vertical, anatomic beef boning, more than 1.5% higher beef yield, less demand for expensive chilling. Both cooler space and energy consumption is drastically reduced. Pre-rigor packed cuts have very low bacterial counts and excellent shelf-life and colour stability. The main part of the meat trimmings (69%) have a total bacteria count (30 °C, 72 hours) lower than 10 000 and less than 20 coliforms per gram. This is a tenth of those for post-rigor beef (Schwencke, 1993).

It is now well documented, (Röpelinen, 1988), that unstimulated, pre-rigor meat trimmings have excellent water binding and fat emulsifying properties, especially when used for direct processing or when sodium chloride is added pre-rigor.

Today, slaughterhouse management requires advanced, rapid, early detection techniques for carcass quality for shipment into export markets, etc., and of those meat cuts to be vacuum-packed. This is now quite possible by the use of the two, above mentioned, simple systems. Normal beef may have an acceptable quality even after 16 weeks in chilled state at -1 °C, just above the freezing point of the meat, if the ultimate pH-value is below 5.8 (Gill and Newton, 1981).

Local electrical stimulation does not reduce the binding properties of the whole carcass. In Finland it is found that electrical stimulation of carcasses reduces the water binding capacity of pre-rigor meat trimmings as well as of the post-rigor meat (Röpelinen, 1988). Stimulation of whole beef carcasses may create some PSE meat (McCormick *et al.*, 1981). A patented machine, using relatively high voltage for stimulation of only the pre-rigor cuts, was fully developed by the author in 1980.

DISCUSSION

Why are there no official regulations on the pH-value of meat? The answer is most likely that there has, up to now, been no suitable method available like these two above machines.

Very early determination the quality of the meat in a whole carcass is of great importance to the meat trade. This is to a certain extent possible by using the two mentioned methods.

It must be stressed that the ultimate-pH-value is not found by using the methods as described above. It has recently been found that Listeria monocytogenes can grow on meat surfaces having a pH-value as low as 5.8 (Kaya and Schmidt, 1990). On the contrary, at this low pH-value the lactobacilli grow fairly well and produce enough lactic acid to reduce the growth of Listeria. Based upon this finding and practical experience (Lövseth, 1989), it is proposed that our "DFD-pH-limit" in Norway of 5.9, should be changed to 5.8,(Braathen and Lövseth, 1989). This is of great importance for reducing the spreading of pathogenic bacteria in meat trade. Carcasses having a pH-value higher than 5.8 should be sorted out immediately, long before any shipping, and cut into trimmings at the earliest possible moment. These facts appear to be ignored by regulators and meat importers. It is postulated that if the existence of these two above methods had been known to the meat industry around the world, the handling of meat would have been totally different. The author first became aware of the DFD problem in 1974 when the pH-value of hygienically first class beef which a very experienced beef boning foreman claimed would spoil very fast (Öien 1974). The pH-value was found to be 6.7. The highest we have found in Norway is 7.25. The pH-value limit 6.0 was introduced in Norway in 1976 when bull carcasses, with a pH-value in the loin above 6.0, on the authors recommendation, were rejected upon import from Poland.

Beef, having a pH-value of 5.90 or higher in Norway and 6.0 in Finland (Röpelinen, 1988), has for several years now been paid at a much lower price. For the time being (1993) the deduction in Norway is NOK 3.50 per kilo on the wholesale carcass price. This corresponds to up to 12% deduction in total carcass value.

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