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mla MEAT & LIVESTOCK AUSTRALIA DONOR COMPANY

final report

Project code: P.PSH.0904

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Date published: 21 December, 2017

PUBLISHED BY
Meat and Livestock Australia Limited
PO Box 1961
NORTH SYDNEY NSW 2059

Frontmatec Beef and Lamb Carcase Ink-jet Printing (stage 1)

Milestone 2 - Final Report evaluating the effectiveness of Frontmatec´s pork Ink-jet printer and ink for printing on beef and lamb primals

This is an MLA Donor Company funded project.

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

The present report describes the possibility of using a DOD7 Ink-jet printer for printing on beef and lamb carcases. Normally, the Ink-jet printer is used for traceability of pork carcases. The use of the printer on beef and lamb primals has not previously been explored.

Right sides of a beef and lamb carcase were used for hot carcase printing and left sides were used for cold carcase printing. Printing was also tested in the abdomical cavity and on cattle skin.

The ink and Ink-jet printer were suitable for printing on both warm and cold beef and lamb carcases. The ink binds to both meat and fat tissue, but the drying time was longer for fat tissue compared to meat. The maximum drying time was 6 min.

Ink-jet printing in the abdominal cavity of lamb was not suitable as the ink did not bind to the tissue and easily smeared upon contact. In beef carcases the position of the print was important as the ink was bound to the tissue when printing occurred on a dry area of the abdominal cavity.

It is not possible to use this ink and Ink-jet printer on cattle skin.

Executive summary

The possibility of using the Frontmatec Ink-jet printer for printing on beef and lamb carcases was explored as part of a MLA funded project (P.PSH.0904). The Ink-jet printer is used world-wide in the pork industry for traceability of pork carcases. The ability to print on beef and lamb primals has not previously been explored.

It is concluded that the ink and Ink-jet printer is suitable for printing on both warm and cold beef and lamb carcases. The ink binds to both meat and fat tissue, with minor differences in drying time depending on tissue types.

This study has provided clear evidence that creates the basis for continuing research and development in this area. Development of an operational prototype (robot) that could be implemented into an Australian facility for printing on beef and lamb primals and sub-primals would be a likely next step. This would ultimately lead to improved traceability and possibly improved yields.

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1 Background

MLA is currently implementing an industry wide program that will ideally result in a significant number of processing plants having beef and lamb DEXA units. These DEXA units will provide the accurate location for cuts however not all processing plants will have automation to realise the benefit of this result. The current project (P.PSH.0904) will commence to evaluate a solution that will use DEXA images to Ink-jet print cutting lines on both beef and lamb carcases for humans (or machines) to read and cut carcases more accurately than is possible today.

For beef, the DEXA units are expected to be on the cold side of the chillers and hence those that can justify automation, can use the DEXA images to drive beef boning automation. For those companies who cannot justify beef automation, or are slow adopters, this project, if successful, will result in an opportunity to print the optimum cutting lines on the beef carcase for operators to then be guided on how best to manually cut up a beef side.

For lamb, the DEXA units are likely to be installed on the hot side of a chiller. If it is possible, through this project, to develop a solution to print the cutting lines on a hot lamb carcase then two opportunities result. For those that are not considering automated lamb boning systems the cutting lines will provide more accurate manual cutting. For those that are considering boning automation, the cutting lines will be able to be picked up by cost effective cameras which can then drive existing advanced x-ray lamb cutting machines, without the need of a second x-ray unit in the boning room.

Finally if the technology is successful, it may be possible to label major primals whilst lamb and beef are full carcases with the Ink-jet printer that in turn enables boning room traceability once the primals have been removed from the carcase.

1.1 Milestone achievement criteria

The milestone achievement criteria for Milestone Report 2 is to submit a final report evaluating the effectiveness of Frontmatec´s pork Ink-jet printer and ink for printing on beef and lamb primals.

2 Project objectives

The participant will achieve the following objective(s) to MLA´s reasonable satisfaction:

- Evaluate the suitability of Frontmatec´s pork Ink-jet printer and evaluate the application of the Ink-jet and Ink-jet printer head to various beef and lamb primals.

- Evaluate the opportunity for this technology to print numbers/labels on various parts of beef and lamb carcases that would enable a certain level of boning room primal traceability of the major primals without need to change boning room infrastructure.

3 Methodology

3.1 Experimental design

The suitability of Frontmatec´s pork Ink-jet printer for printing on beef and lamb primals was evaluated on one beef and one lamb carcase. With Ink-jet it is possible to print on curved surfaces which frequently appear on carcases.

3.1.1 Animal material

At the day of slaughter, a beef carcase and a lamb carcase were randomly selected for the test by a commercial small-scale slaughterhouse (Harald Hansens Eftf., Slangerup, Denmark).

The carcases underwent the normal slaughter procedures and after opening and removal of intestines, the right sides of the carcases were exposed to hot carcase printing. Printing was performed 1 hour after de-hiding on the beef carcase and approximately 15 min after slaughter on the lamb carcase. The carcases were then stored in the cold room (7°C) overnight and on day 1 after slaughter the left sides of the corresponding right sides were exposed to cold carcase printing. In addition, the condition of the prints on the right sides were evaluated on the day after slaughter in the cold room.

It should be noted, that the carcases were not irrigated with water at any time during slaughter and cold storage. The carcase surface therefore appeared rather dry which most likely affected the dye binding abilities positively.

3.1.2 Ink-jet printer

Fig. 1 shows the print setup used for the stage 1 test reported here.

Fig. 1. Ink-jet printer setup

The setup consists of three main components:

1. Ink-jet cartridge
2. DOD7 print head
3. Portable control unit

In the current test, the Ink-jet technology is used for printing a sequential kill number on the beef and lamb carcase. Using Ink-jet instead of a fixed stamp enables change of characters between each carcase. The kill number in the current test consist of one letter (A) and a two-digit number. The kill number increment automatically by one when activation is triggered.

The ink (Fig. 1, 1) has a brown color (Product code B59011, Matthews Swedot AB, Sweden) and is approved for use in the food industry and comply with Regulation (EC) No 1935/2004. The ink solution is composed of Water (< 70%), Ethanol (> 25%), Glycerine (< 2%), C.I. Foodblue 2 (< 0.2%) and C.I. Foodred 17 (< 1.5%). The ink is already used by Frontmatec for printing on hot pig carcases in their AutoMarker M1 product.

The DOD7 (drop on demand) print head (Fig. 1, 2) has 7 nozzles. Each nozzle prints a single dot, hence the characters from the print heads will be up to 7 dots high. Each printed character can be up to 28mm high.

The Ink-jet cartridge comes with an approximately 4 bar pressure. During the printing process, the pressure forces ink from the cartridge into the print head and out of the nozzles. The portable control unit (Fig. 1, 3) comprise an electrical unit which activates the Ink-jet printer upon activation of a trigger.

In the AutoMarker M1 the ink pressure is 0.3 bar. The pressure is therefore much higher in the test setup compared to normal conditions during production. Therefore, more ink is printed on the carcase in the present test set-up and this has given rise to excess dye on the print.

3.1.3 Ink-jet printing on carcases

Ink-jet printing was performed on 3 primal cuts in lamb carcases (Shoulder, back, leg) and on 4 primal beef cuts (shoulder, short loin, rump, short plate). In addition, the ability to print on the ribs in the abdominal cavity was investigated. As mentioned previously, printing was done on both hot and cold carcases.

Furthermore, it was decided to explore if it would be possible to print on live cattle in the future. Therefore, printing was performed on cattle skin.

3.1.4 Evaluation parameters

The suitability of the Ink-jet printer to print on beef and lamb carcases were evaluated using the following parameters:

1. Drying time expressed as total time in minutes from printing to complete drying of the ink
2. Readability of the print
3. Difference between printing on meat and fat tissue

Bullet points 2 and 3 were visually assessed while bullet point 1 was determined using a timer. The evaluation of the ink drying time was assessed by contact (pulling a finger over the print area) and the presence of smearing was determined (Fig. 2).

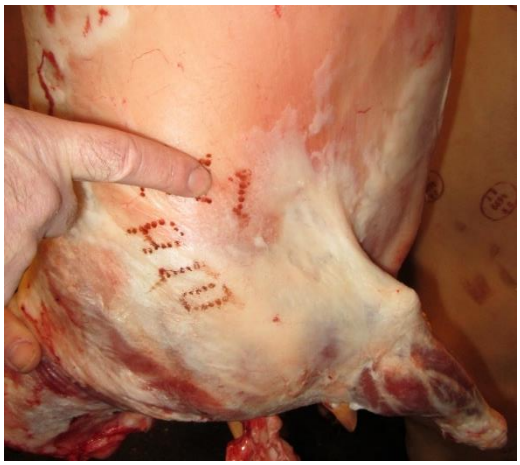

Fig. 2. Illustration of how the ink drying time after printing was evaluated.

4 Results and Discussion

4.1 Ink-jet printing on lamb carcase

4.1.1 Warm lamb carcase

The images captured immediately after Ink-jet printing on the three primals (Shoulder, back, leg) of a warm lamb carcase are shown in Fig. 3.

Fig. 3. Ink-jet printing on a warm lamb carcase immediately after slaughter. Top left: Carcase before printing; Top right: shoulder; Bottom left: back; Bottom right: leg. Images are captured immediately after printing.

As can be seen from Fig. 3 the print is readable on all cuts and no smearing occur. The time from printing to complete drying of the ink was maximum 4 min depending on the type of tissue (fat or meat). Due to the thin subcutaneous fat cover the ink on the back was dry already after 2 min. The shoulder had a part with no fat cover and a part with more fat (Fig. 3 & 4). The ink was dry already after 2 min on the meat, but 4 min was needed for ink to dry on the fat tissue. The drying time was examined after 2 min and therefore some smearing can be seen on the fat tissue, as the ink was not dry yet (Fig. 4). The leg was covered in subcutaneous fat, and hence the drying time was 4 min (Fig. 4).

Fig. 4. Ink-jet printing on a warm lamb carcase immediately after slaughter. Top left: shoulder; Top right: back; Bottom left: leg. Images are captured 4 minutes after printing.

The ability to use the Ink-jet printer for labelling in the abdominal cavity on the ribs were also examined (Fig. 5).

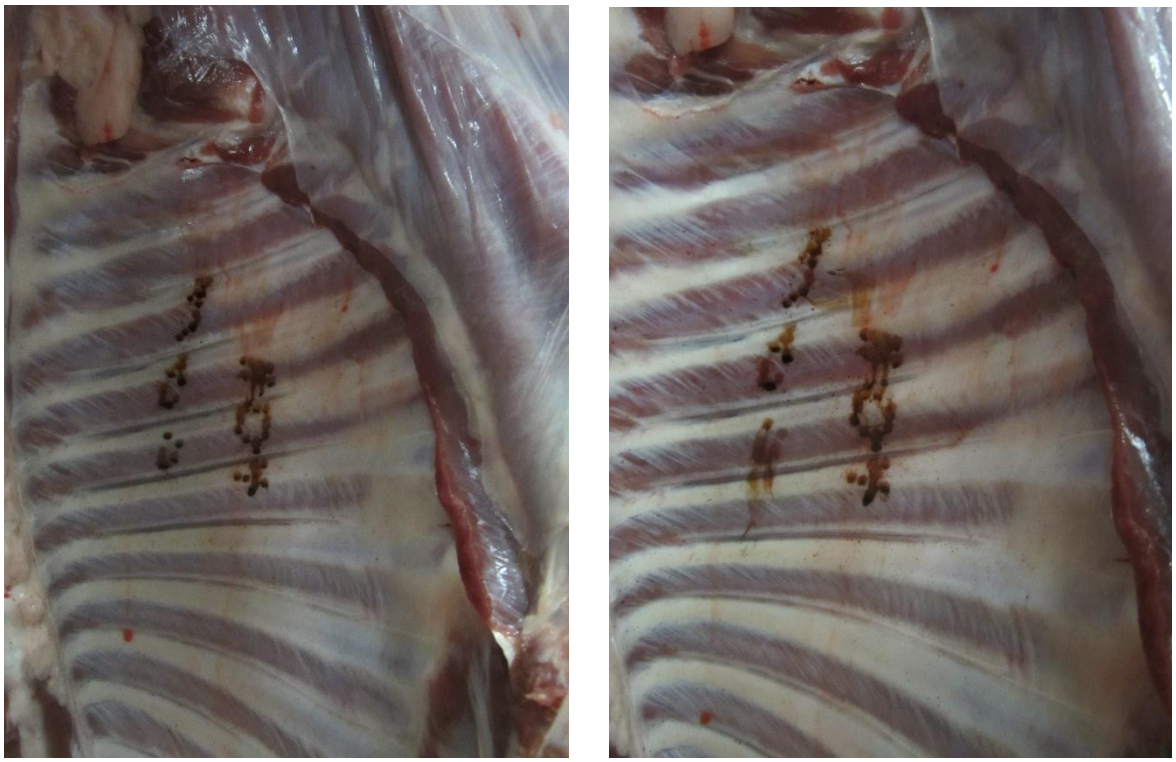

Fig. 5. Ink-jet printing in the abdominal cavity on a warm lamb carcase immediately after slaughter. Left: image captured immediately after printing; Right: image captured 4 minutes after printing.

Fig. 5 reveals that the ink is not binding to the tissue in the abdominal cavity and the ink runs as soon as it is applied due to lack of its binding capability.

On the day after slaughter, the stability of the print applied at the day of slaughter was evaluated in the cold room (Fig. 6). As can be seen, the prints on the three primals are readable, and the ink does not seem to have changed overnight. The print in the abdominal cavity is not readable.

Fig. 6. The stability of the ink printed on a warm lamb carcase and evaluated after 1 day of storage in the cold room. Top left: shoulder; Top right: back; Bottom left: leg; Bottom right: abdominal cavity. Images were captured in the cold room 1 days after printing.

4.1.2 Cold lamb carcase

The images captured immediately after Ink-jet printing on the three primals (Shoulder, back, leg) of a cold lamb carcase is shown in Fig. 7.

Fig. 7. Ink-jet printing on a cold lamb carcase 1 day after slaughter. Top left: Carcase before printing; Top right: shoulder; Bottom left: back; Bottom right: leg. Images are captured immediately after printing.

As can be seen from Fig. 7 the print is readable on all cuts and no smearing occurs. The time from printing to complete drying of the ink was maximum 6 min depending on the type of tissue (fat or

meat). The ink dried after 2 min when printing was done on meat. The drying time for back was longer than for the other cuts. This is likely caused by a pronounced subcutaneous fat layer on the back. The drying time was examined after 2 min and therefore some smearing can be seen on the fat tissue of the back, as the ink was not dry yet after this time (Fig. 8).

Fig. 8. Ink-jet printing on a cold lamb carcase 1-day after slaughter. Top left: shoulder; Top right: back; Bottom left: leg. Images are captured 6 minutes after printing.

The ability to use the Ink-jet printer for labelling in the abdominal cavity on the ribs were also examined in the cold lamb carcase (Fig. 9).

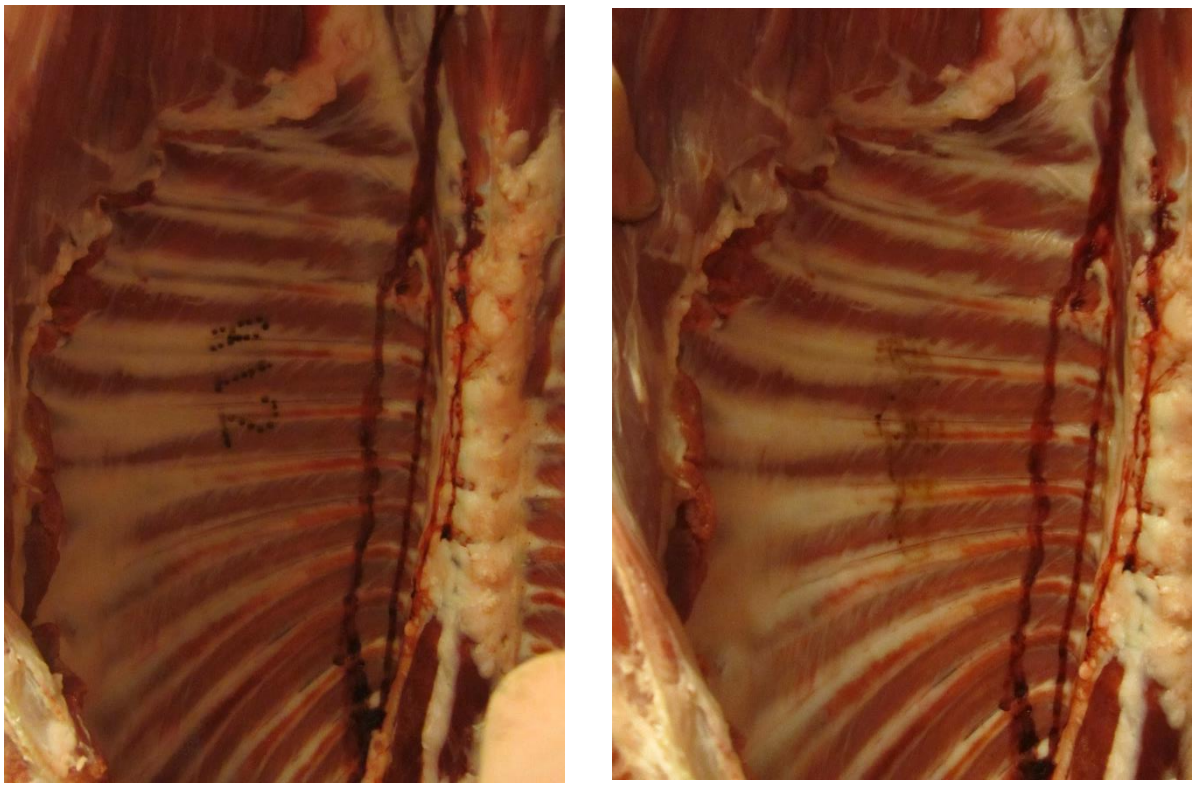

Fig. 9. Ink-jet printing in the abdominal cavity on a cold lamb carcase 1 day after slaughter. Left: image captured immediately after printing; Right: image captured 6 minutes after printing.

The stability of the print applied on the cold lamb carcase was evaluated (Fig. 9). As can be seen, the print is readable after printing. However, after 6 min drying time the print is still readable but when a finger is pulled over the print it becomes smeared and unreadable. This is due to lack of dye binding to the tissue.

4.2 Ink-jet printing on beef carcase

4.2.1 Warm beef carcase

The images captured immediately after Ink-jet printing on the four primals (shoulder, short loin, rump, short plate) of a warm beef carcase are shown in Fig. 10.

Fig. 10. Ink-jet printing on a warm beef carcase 1 hour after de-hiding. Top left: Carcase before printing; Top middle: shoulder; Top right: short plate; Bottom left: short loin; Bottom right: rump. Images are captured immediately after printing.

The binding of ink occurred rapidly on all four primals of the warm beef carcase and all prints were readable with no smearing. No difference in binding time between fat and meat tissue was observed and the ink was dry within 6 min on all primals. Fig. 11 shows the print after 6 min of drying time.

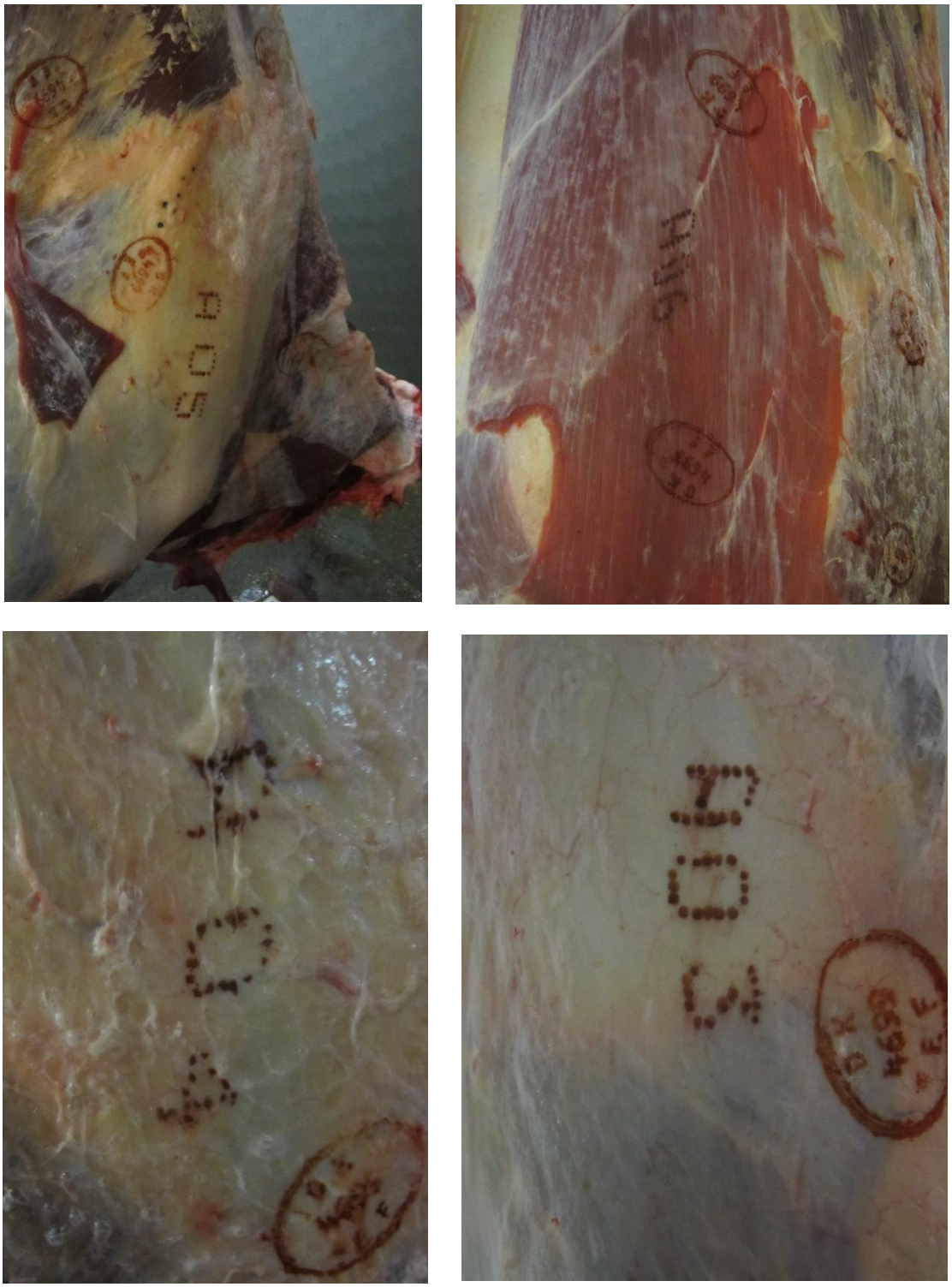

Fig. 11. Ink-jet printing on a warm beef carcase 1 hour after de-hiding. Top left: shoulder; Top right: short plate; Bottom left: short loin; Bottom right: rump. Images are captured 6 minutes after printing.

The ability to use the Ink-jet printer for labelling in the abdominal cavity on the ribs of a warm beef carcase was also examined (Fig. 12).

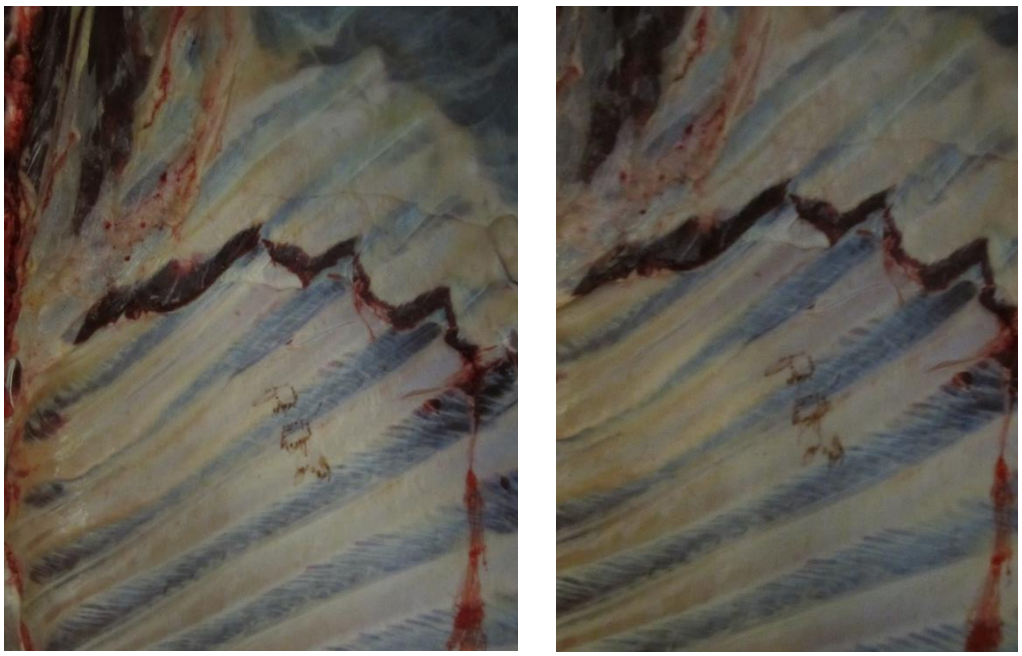

Fig. 12. Ink-jet printing in the abdominal cavity of a warm beef carcase 1 hour after de-hiding. Left: image captured immediately after printing; Right: image captured 6 minutes after printing.

As can be seen on Fig. 12 the ink is running immediately after printing in the abdominal cavity probably due to the wet surface. The print is readable, but it smeared upon contact and became unreadable (image not shown).

On the day after slaughter, the stability of the print applied on the warm beef carcase was evaluated in the cold room (Fig. 13). As can be seen, the prints on the four primals are readable, and the ink has not changed overnight. The print in the abdominal cavity is not readable (image not shown).

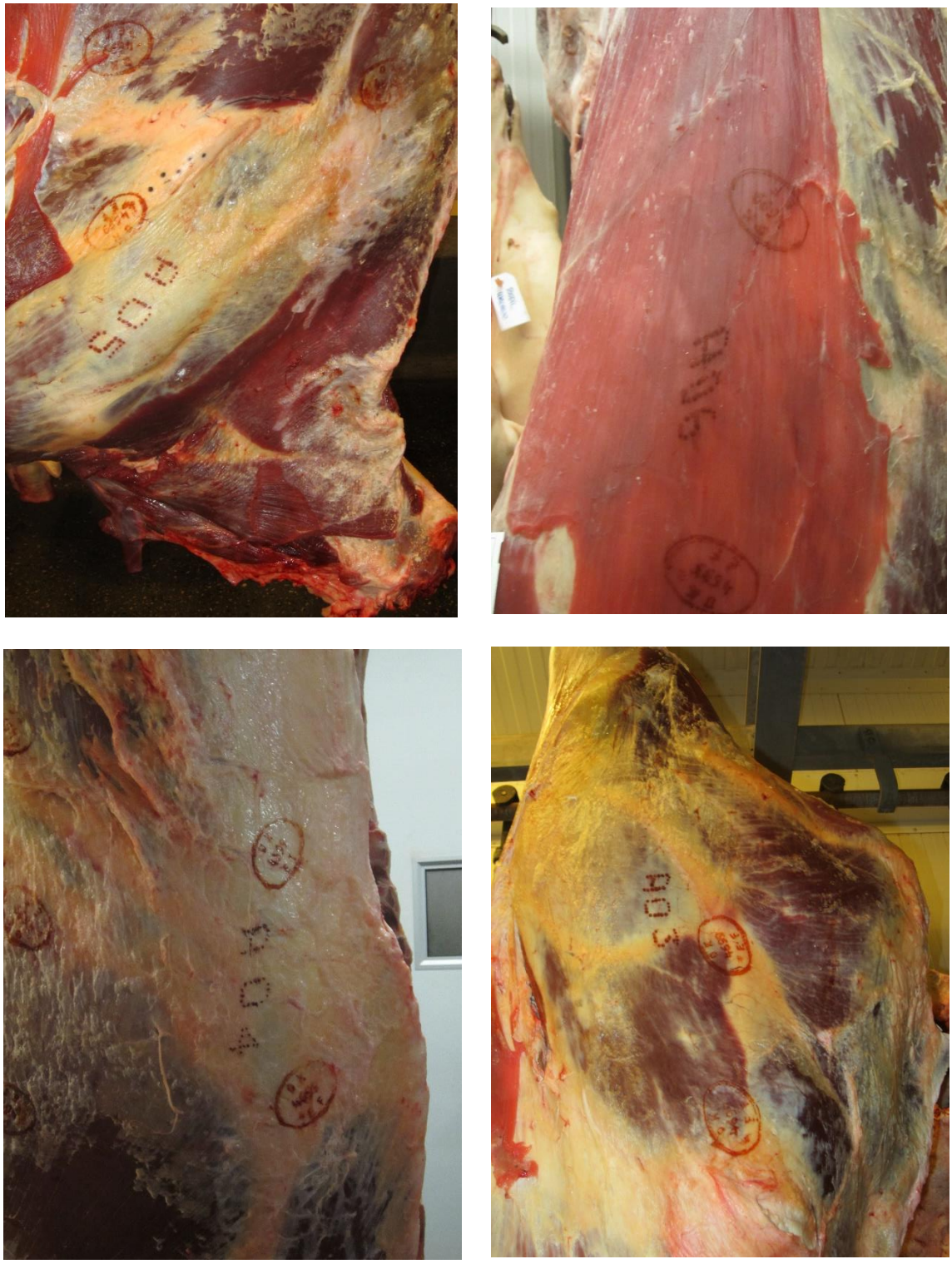

Fig. 13. Evaluation of the stability of the ink applied to a warm beef carcase and stored over-night in the cold room. Top left: shoulder; Top right: short plate; Bottom left: short loin; Bottom right: rump. Images were captured in the cold room.

4.2.2 Cold beef carcase

The images captured immediately after Ink-jet printing on the four primals (shoulder, short loin, rump, short plate) on the cold beef carcase are shown in Fig. 14.

Fig. 14. Ink-jet printing on a cold beef carcase 1 day after slaughter. Top left: Carcase before printing; Top middle: shoulder; Top right: short plate; Bottom left: short loin; Bottom right: rump. Images are captured immediately after printing.

As can be seen from Fig. 14 the print is readable on all cuts and no smearing occurs. The time from printing to complete drying of the ink was maximum 6 min depending on the type of tissue (fat or meat). The drying time was examined after 2 min and therefore some smearing can be seen on the fat tissue of the shoulder, as the ink was not dry yet (Fig. 15).

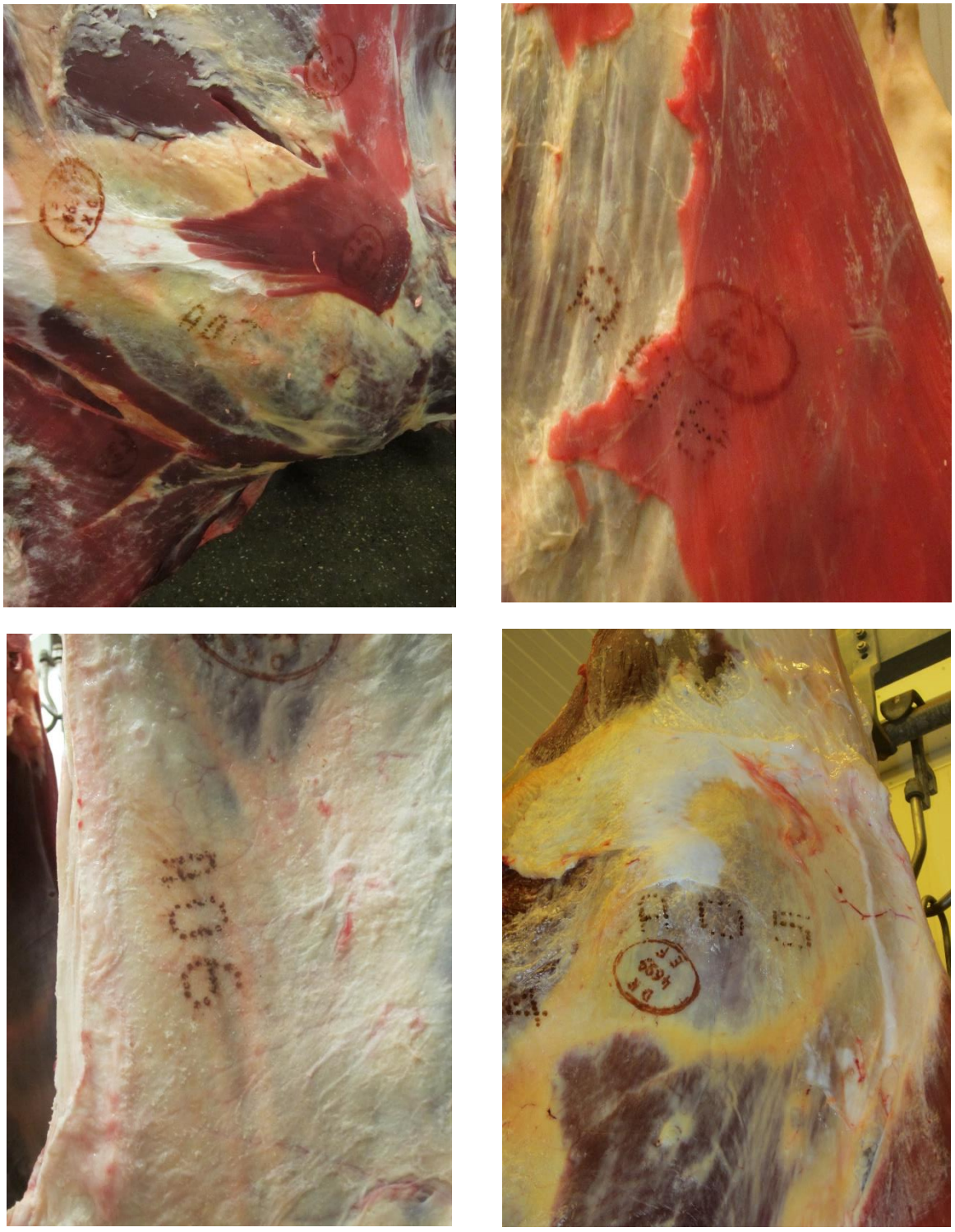

Fig. 15. Ink-jet printing on a cold beef carcase 1 day after slaughter. Top left: shoulder; Top right: short plate; Bottom left: short loin; Bottom right: rump. Images are captured 6 minutes after printing.

The ability to use the Ink-jet printer for labelling in the abdominal cavity on the ribs were also examined in the cold beef carcase (Fig. 16).

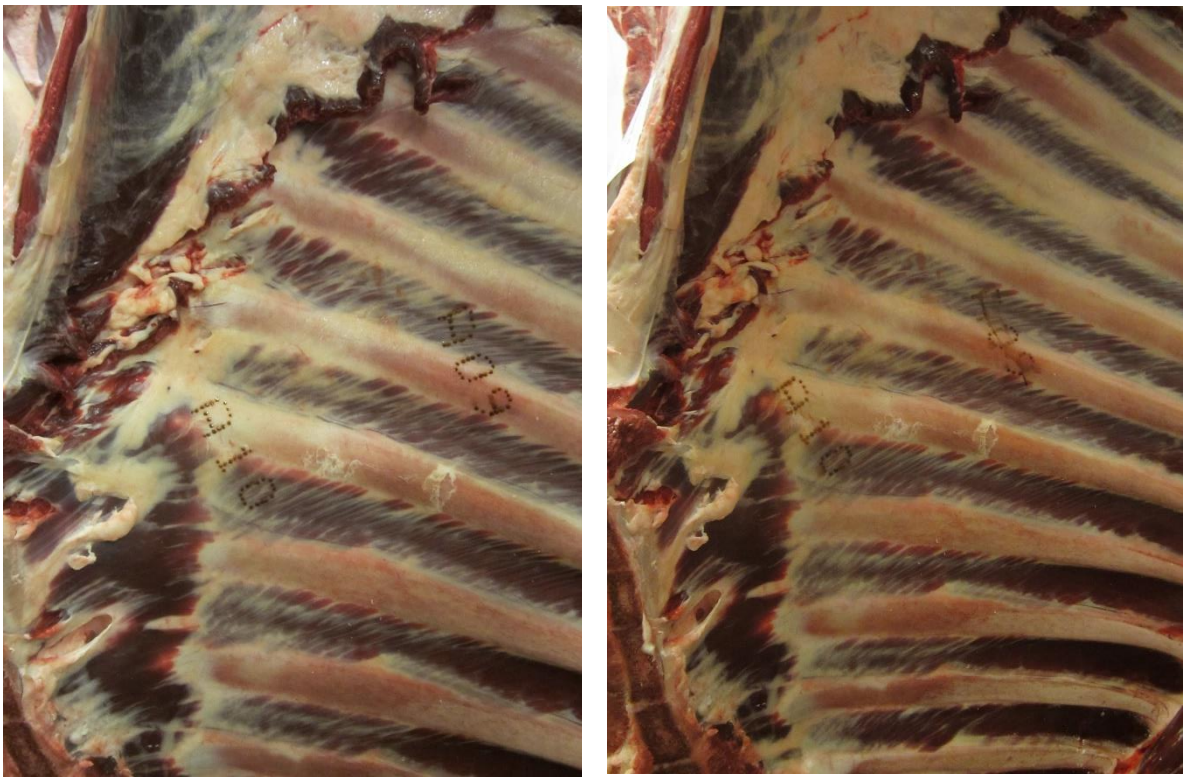

Fig. 16. Ink-jet printing in the abdominal cavity on a cold beef carcase. Left: image captured immediately after printing; Right: image captured 8 minutes after printing.

The print is readable for both print A09 and A10 (Fig. 16, left). After 2 min, dye binding occurs for the print A10 and it is not possible to smear the print during contact (Fig. 16, right). However, for print A09 the ink does not bind as good and after 8 min drying time the print is smeared upon contact (Fig. 16, right). In the area where the A10 label is printed the surface appears drier and that is believed to affect the binding capacity of the ink positively. In the area where A09 is printed the surface is wet and the ink can therefore not bind. This result suggests that the position of the print inside the abdominal cavity is important. It seems possible to print inside the abdominal cavity if an area can be found which is dry enabling good binding of the ink.

4.3 Ink-jet printing on skin

Ink-jet printing was performed on cattle skin (Fig. 17) to investigate if it would be possible to label live cattle with an ID number.

Fig. 17. Ink-jet printing on cattle skin immediately after de-hiding of a beef carcase. Top left: cattle skin without print; Top right: Image captured immediately after printing on the skin; Bottom left: image captured 6 minutes after printing.

As shown in Fig. 17 the print is readable on light areas of the cattle skin. However, the ink does not bind to the fur and therefore the print is smeared and can be removed completely during contact. It is therefore concluded that the ink and the DOD7 printhead cannot be used for ID labelling of live cattle.

5 Conclusions/recommendations

5.1 Use of Ink-jet printing and ink for printing on lamb and beef carcases

The ink and Ink-jet printer are suitable for printing on both warm and cold beef and lamb carcases when irrigation with water during slaughtering and cold storage is avoided. The ink binds to both meat and fat tissue but the drying time depends on the tissue type. In the present study the maximum drying time on primals was 6 min.

Ink-jet printing in the abdominal cavity of lamb was not suitable as the ink did not bind to the tissue and therefore could easily be smeared upon contact. In beef carcases it seemed that the position of

the print was important as the ink was bound to the tissue when printing occurred on a dry area in the cold carcase. If the printing area was wet the ink did not bind properly.

Printing on cattle skin is not possible as the ink does not bind, and the print gets smeared during contact.

5.2 Recommendations for new research and development

This report presents the results and conclusions of the stage 1 project “Frontmatec beef and lamb carcase Ink-jet printing”. The overall conclusion of this project is that the Ink-jet printer and Ink-jet is suitable for printing on beef and lamb primals.

This first stage project has provided necessary evidence for developing a stage 2 project. The second stage would include development of an operational prototype (robot). The robot would initially be pilot tested in a European beef slaughter house. The ability to label primals and sub-primals consistently as well as marking the cutting lines using proxy DEXA information would be the expected outcome. If the pilot test turns out positive, a final stage 3 project would evolve. The prototype would be installed at an Australian slaughter house and traceability and yield of primals and sub-primals would be evaluated.

6 Key messages

6.1 Ink-jet printing on beef and lamb carcases

The ink and Ink-jet cartridge used by Frontmatec for printing on hot pig carcasses in their AutoMarker M1 product is suitable for printing on both warm and cold beef and lamb carcasses.

The ink binds to both meat and fat tissue. However, minor differences in drying time appears depending on tissue types.

Clear evidence has been provided in this final report which creates the basis for continuing research and development in this area.

6.2 Ink-jet printing on beef skin

The ink and Ink-jet printer is not suitable for printing on beef skin.