TO INVESTIGATE THE POTENTIAL USE OF FOOD QUALITY COLOURINGS (DYES) FOR STAINING VERTEBRAL COLUMNS OF OVER THIRTY MONTH CATTLE PRESENTED FOR SLAUGHTER AND HUMAN CONSUMPTION

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Alan V. Fisher, Principal Investigator

Division of Farm Animal Science
School of Veterinary Science
The University of Bristol
Langford
Bristol BS40 5DU

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1. Executive summary

2. Glossary

MLC Meat and Livestock Commission
OTM over 30 month rule that prohibits cattle older than this from entering the food chain
SRM Specified Risk Material (tissues/organs that are prohibited from entering the food chain)
VC vertebral column

3. Aims and Objectives

An important conclusion from Food Standards Agency funded research is that replacing OTM with BSE testing of cattle over 30 months of age will result in only a very small increase in estimated vCJD cases. The Agency's Board therefore agreed to recommend to Ministers that it would be acceptable, on public health grounds, to go down this route. At the time of writing, no decision has been made to change the legislation but if older cattle are allowed back in the food chain there is a likelihood that the VC from such cattle will be designated as SRM and will therefore need to be removed before the product enters the chain. Execution and auditing of the removal process would be facilitated by a clear visual signal that distinguishes these VC from those in carcass sides from under 30 month cattle. The overall objective of this project was, therefore, to evaluate different methods of marking the VC in beef sides.

Limited preliminary work by the MLC on the suitability of food grade dyes to mark the VC had shown that certain dyes were better than others in terms of stability and visual clarity. Briefly, the conclusion of that early work was that the MM Allura Red dye had the best colour stability but was not

recommended as it was difficult to distinguish from blood staining. The MM Brown dye had the worst colour stability and was difficult to distinguish from the general colour of bone. There was little difference between the required attributes of MM Green, the yellow dye and MM Brilliant Blue dyes but yellow and blue dyes are already used in meat plants (to stain OTM carcasses and SRM (Patent Blue) or the health mark on dark meat (Brilliant Blue), respectively). MM Green was the only dye to emerge from this trial as a potential marker for use on VCs but a purple dye, specifically made for the purpose, was not tested by the MLC but was considered *a priori* to be worth investigating. During the early stages of our follow-up project, an orange dye was produced by mixing the MM Red and MM Yellow dyes and was considered to offer potential. An orange dye was, therefore, also included in the study but because it was not part of the agreed Scope of Works the results for this dye are included in an Appendix.

This project extended the evaluation of dyes and also included alternative, novel methods of marking VCs as possible solutions.

4. Experimental procedures, results and discussion on a Task by Task basis

4.1. All the dyes used in this project, with the exception of the orange dye, were supplied to us by the MLC and were the same dyes used by the Commission in their preliminary trials. The orange dye was obtained directly from the manufacturer. All dyes, apart from the yellow, were manufactured by

Roger Needham & Sons Ltd
Unit 2b, Civic Industrial Park
Waymills
Whitchurch
SY13 1TT

The yellow dye was manufactured by

Fiorio Colori
Code 20060
Gessate
Via Italia 28
Italy

and was imported by Packers of Preston.

4.2. Objective/Task 01. Preliminary evaluation of the suitability of a purple dye (MM Purple) for staining the vertebral column of beef sides.

Three carcasses were used to assess the properties of MM Purple and to determine if this colour could be readily differentiated from MM Brilliant Blue. For each carcass, the VC in one side was stained blue and the other side was stained purple, the dyes being applied after carcass washing (Fig. 1). For the first carcass, dyes were applied using a 110mm wide x 35mm diameter

sponge roller and for the second and third carcasses they were applied by a 12mm wide paint brush. The stain was applied to the main bodies of the vertebrae (the centra, situated ventrally to the spinal canal). Application was quicker with the roller than with the brush but even the latter could be accomplished in less than 30 seconds. The VCs were examined at three time points after marking – immediately, after 48 hours and after 5 days in a chill room operating at 2 ± 2^0C. Two assessors[1] independently scored individual VCs for colour identity using a 5-point scale (score 1 = poor to 5 = good) and compared the two stained VCs from the same carcass (1 = no apparent difference to 5 = no possibility of confusion). The results are shown in Table 1.

The colour identity of the VCs dyed blue was stronger than those dyed purple, with overall scores for colour identity of about 4.5 and 3, respectively. Assessor A made comments that the purple could be confused with black[2] and consistently gave lower scores for purple identity than assessor B, whereas, in most cases, assessor B scored the blue dye identity lower than assessor A because it was 'turquoise-like' and could be confused with green. There were high scores by both assessors for the colour comparison, indicating that blue and purple are unlikely to be confused.

As an additional exercise to the main activities in this Task, the two sides from the second carcass were cut into primal joints and three additional persons (members of the DFAS slaughter and dissection teams, coded as Assessors C, D and E) were asked to score the joints for colour identity and to compare the VCs in the same joints from the two sides using the same scales as in Table 1. The results (Table 2) reflect those obtained from the assessment of VCs in carcass sides, namely that the colour identity scores are lower for the purple dye than for the blue, with overall means very similar to those in the previous assessments (4.3 for the blue and 2.4 for the purple). There was some indication of variation between joints with two of the assessors (D and E) scoring the purple colour identity lowest in the chuck and forerib joints. All three assessors were able to clearly distinguish between the blue and the purple dyed VCs (Fig.2). The conclusions from these results are that VCs dyed with MM Purple can be easily distinguished from VCs dyed with MM Brilliant Blue. However, the colour of MM Purple was not readily perceived by the assessors as being purple and could, in their opinion, based on normal, everyday exposure to and recognition of colours, have been confused with black. It is therefore unsuitable for marking a specific category of carcass.

[1] Coded as Assessors A and B. Both were assessed as having superior vision in a colour test

[2] Diluted solutions of the purple dye to 50 and 25% of the original concentration were not noticeably easier to distinguish from black than the undiluted purple dye.

4.3 Objective/Task 02. Evaluate the performance of a green dye (MM Green) with particular regard to cross-transfer and identification reliability during carcass handling up to the point of boning

Seven carcasses were used to determine the performance of the green dye when beef sides were moved along the overhead rail system into chill rooms (cross contamination) following slaughter and dressing. The experimental design is shown schematically in Figure 3. The first carcass was a control and neither side was dyed; they were moved alone to the chill room following slaughter, without contact with other carcass sides. The second carcass was also a control (not dyed) but the two sides were interspersed between other dyed sides as shown in Figure 3. The remaining five carcasses had both sides dyed with MM Green after the wash following carcass splitting (Fig.4). Five sides were dyed using the brush and five were dyed using the roller described under Objective 01. The allocation of right/left sides to treatments and the order and orientation of the sides prior to moving them to the chill room as two batches of six sides is shown in Figure 3.

After pushing the sides towards the chill room they were inspected and their appearance was assessed. The adherence and colour identity were assessed by the same persons (assessors A and B), and using the same five point scales, as in Objective 01. Assessments were repeated at 48 hours and 5 days post mortem. The results are shown in Table 3.

There was no visible dye on the isolated controls. On the medial surface of all the dyed sides (prefixed by 'D'), the green colour was easily discernible and both assessors gave high scores (4 or 5) for all sides at all time points. There was some indication of the colour changing or fading with time in the opinion of Assessor B (but not Assessor A). There was no difference in colour scores for the VCs between brush and roller dyed sides.

The scores indicating cross contamination of dye between sides, or onto the hands of the operator who pushed the sides along the rail, are shown in red in Table 3. There were two possibilities per batch of six sides for dye to be transferred from the VC of one side to the lateral surface of another. In Batch 1 this was from D6 to D5 and from D5 to D4; in Batch 2 it was from D4 to D5 and from D7 to D3. Similarly, transfer to the lateral surface of the controls was possible from D3 in Batch 1 and from D3 in Batch 2 but for the controls contamination of the medial surface was also possible (from D4 in Batch 1 and from D5 in Batch 2). Inspection of Table 3 shows that transfer of dye did, in fact, occur in each of these instances and was, for the most part, reasonably substantial with scores of 3-4. There was some evidence that cross-transfer was less in Batch 2 (roller dyed), particularly to the control carcass (scores 1-2 and 2-3 for the medial and lateral surfaces, respectively, compared with corresponding scores of 2 and 3-4 for the control in Batch 1 (brush dyed)). The same was true for transfer to the operator's hands, with scores of 1-3 in Batch 2 and 2-3 in batch 1.

The conclusion from this task is that there is transfer of dye between carcasses and also onto the operative's hands when sides are pushed along the rail to the chill room in batches, as frequently happens in commercial abattoirs. Because of the convex shape of the lateral surface of a beef side and the concave shape of the medial surface, cross transfer of dye occurs most readily from medial to lateral. However, it is possible for some dye to transfer to the medial surface and hence possibly to the vertebral column giving false positives. There is also a serious disadvantage to the industry if the dye transfers to the meat surface as costly trimming will be necessary to remove the dye, in spite of it being food grade.

4.4 Objective/Task 03. Evaluate the impact of green-dyed vertebrae on the appearance of meat joints after jointing.

Ten sides were used in this evaluation. There were two methods of applying the dye – brush and roller, and two boning times – 48 hours and 5 days (nominal – 6 days in practice, for practical reasons). The experimental design ensured that each of these variables was contrasted within carcass, i.e. if side A was brush, 48h, side B would be roller, 6d. In total, the number of sides per treatment were:

2 x Brush, 48h
3 x Brush, 6d
3 x Roller, 48h
2 x Roller, 6d

The possibility was that dye could transfer from the primary areas on the side (mainly the cut face of the VCs but some lateral areas on one side per carcass) to the cutting table, to the operator's hands, and to the surfaces of the joints. The delayed jointing of half the sides to 6 days would possibly allow the dye to dry more thoroughly and thereby reduce its spread. All sides were prepared by the same operative who cut them to yield the joints listed in Table 4. The cutting table was washed after each side had been prepared. The first batch of six sides was used to assess the problem qualitatively and it became apparent that contamination of the joints was manifest as two basic forms: small particulate matter (numerous, Fig. 5) and larger smears (uncommon, Fig. 7). It was thought that some, if not most, of the particulate matter was bone, tiny fragments produced either when the carcass was split by the bandsaw, and not removed during the final carcass wash, or when the vertebral column was sawn in the separation of joints. These fragments transfer to the table and operative's hands during butchery, and then to the surface of the joints. The smears would have resulted from direct contact of the joint with the dye on other parts of the carcass, on the table (Fig. 10) or on the operative's hands. There was also dye on the cutting table and on the operative's hands after the completion of a side. Most contamination was on the superficial fat (subcutaneous fat) but some was on muscle (Figs. 6 and 8).

Quantitative assessment of contamination was undertaken for the four subsequent sides. Two assessors (A and B) thoroughly examined each joint

after removal from the side and scored the degree of contamination on a scale ranging from 1 = no visible contamination to 5 = extensive contamination dispersed over entire joint surface. In practice, it was felt necessary to include intermediate scores or half-scores as most of the ratings were clustered towards the lower end of the scale because contamination was generally light and intermediate scores allowed better discrimination. A frequent score awarded (by both assessors independently) was 1-2 which equated to just one or two very small specks of visible green and the highest score awarded was 3-4, indicative of larger area(s) of smeared dye and/or widespread speckling. The results of these assessments are shown in Table 4.

There was generally good agreement between the two assessors' ratings. There was detectable contamination on every joint from at least one carcass side. Contamination tended to be lower on the distal limb joints, the leg and shin, as these do not touch the cutting table during removal and only slight contamination was noted in one side. The fillet and the rump tended to have the highest levels of contamination. There were no consistent differences between sides dyed by brush or by roller; sides cut at 6 days tended to have more contamination than those cut at 48 hours, perhaps a surprising result as it might be thought that the longer storage period would have resulted in the dye drying more completely and therefore being less likely to transfer to other surfaces. It is not known if the explanation lies in a change of dye properties occurring over the extra four days.

The conclusion from this task is that the dye does not adhere permanently to the vertebral cut surfaces and it transfers during carcass jointing, albeit in small amounts in the majority of cases. It is likely that this will be further reduced when the joints are prepared for retail sale as some of the superficial tissues, particularly the subcutaneous fat, will be trimmed off the joints. However, there will always be a risk of some contamination and because it is green, it could be associated with mould in the minds of consumers.

An additional observation was that vacuum packing the joints (a common practice following jointing into primals and boning out) exacerbated the appearance of particulate contamination presumably because the plastic film under pressure squeezes the dyed tissue fragment onto the meat surface, causing it to spread. This 'halo' effect is shown in Fig. 9.

4.5 Objective/Task 04. Evaluate the performance of the purple dye (MM Purple) with particular regard to cross-transfer and identification reliability during carcass handling up to the point of boning (dependent on results from Objective 01)

The results of Task 01 showed that the purple dye was unsuitable and it was, therefore, not evaluated in Objective 04.

4.6 Objective/Task 05. Evaluate the impact of purple-dyed vertebrae on the appearance of meat joints after boning (dependent on results from Objective 01)

The results of Task 01 showed that the purple dye was unsuitable and it was, therefore, not evaluated in Objective 05.

4.7 Objective/Task 06. Evaluate alternative methods of marking vertebral column of beef sides

This objective was included as a contingency measure should the use of dyes prove to be unsuccessful. Two alternative methods of marking the VCs were proposed, namely marking the surface of the vertebral canal using meat marking pencils or dyes and scoring the vertebrae by mechanically cutting a groove along the entire length of the column. The latter provides a signal that is still a visual one although it could also be perceived by palpation. Not only would this avoid problems of 'signal' confusion (which can happen through cross contamination when using dyes) but it would also be detectable by those male operators who suffer from the most common form of colour-sense deficiency, red-green colour 'blindness'. As one of the proposed dyes is green, and about 10% of males suffer this form of colour deficiency, this alternative method may offer a substantial advantage

One carcass was dressed and split using a bandsaw in the conventional manner. The spinal cord was removed from both sides. The entire vertebral column of the right side was marked using an electrically powered angle grinder. A groove was cut along the chain of vertebral centra, extending from sacral vertebra 5 to cervical vertebra 1, using a 3mm thick masonry cutting disk (Fig 11). This operation took 23 sec. The medial surface of the side was then washed.

The medial surface of the left side was also washed and the entire spinal canal was marked with a blue meat marking pencil (A.W. Faber-Castell GmbH & Co, Nűrnberg) (Fig.15). The visibility of the cut groove and the stained spinal canal was scored by two assessors, one from the University of Bristol and one from the Meat and Livestock Commission, using a 5-point scale in which 1 = no obvious mark to 5 = very obvious mark. Both sides were then chilled as normal (2 ± 2^0C).

Repeat visibility assessments were made after 48 hours chilled storage. Both sides were cut into bone-in primal joints after 48 hours, and members of the butchery staff were asked to comment on the ease of recognition of marks on individual joints containing vertebral column.

A second carcass was used in a repeat of the above but a brown meat marking pencil, from the same manufacturer, was used (Fig. 16) and there was an additional assessment at 6 days post mortem, prior to jointing. The results for this Task are shown in Table 5.

Immediately after marking, both the cut groove and the blue pencil mark were quite obvious (scores 3-4 or 4-5). However, both of these marks had faded by 48 hours, the blue pencil mark more so than the groove and there was no evidence to suggest that the groove had faded further between 48 hours and 6 days (Figs. 11 and 12). The reason for the decline in visibility appeared to be a general darkening/reddening of the cut vertebral column with time, as blood gradually diffused from vertebral capillaries. In fact, this was an early event post mortem and it was noticeable that only some minutes after being so marked, the visible identity of the groove had diminished as it darkened.

The brown pencil was not obvious and received a score of 1 (Table 5), a score that did not change with time (Figs.16 and 17).

There were two subsequent actions in the execution of this Task. As it will be necessary to sterilize any marking equipment between carcasses, a pneumatic grinder (to compare with the electrically powered one used earlier) was used to mark a further couple of sides. This was a Draper 4" Air Angle Grinder (Part No. 4207) and was operated from the abattoir compressed air supply (manufacturer's instructions specify a maximum pressure of 90 psi). One side was marked using a 3mm thick masonry cutting disc, the other with a 5mm thick metal grinding disk. Both worked reasonably well but the masonry disc was better suited to cutting bone (Fig.13); however, the wider groove produced by the metal cutting disc was more desirable (Fig. 14). Ideally, a thicker masonry disc would be used as it would leave a deeper and wider groove. It is not known what all the disc options are. These grinders are readily available in DIY stores and builders' merchants and prices start from around £60.

The grinders do produce bone dust and it might be considered necessary to play a water jet over the bone to reduce this.

The other action was to mark the spinal canal using the same green dye that had also been used to mark the centra of the vertebrae. One side of a carcass was so marked using a 12mm paint brush. It was clear from inspection that a 12mm brush would, to some extent, contaminate the face of the vertebral column with dye. To confine the dye to the lining of the spinal canal, thus preventing it from transferring to the cutting table or other meat during carcass handling and butchery, the width of the tip of the bristles was reduced from 12mm to approximately 10mm. This was achieved by binding the bristles together with adhesive tape about 13mm from the bristle ends. The 10mm tip was roughly circular in cross-section, as opposed to being relatively flattened as in a normal paint brush, and could hold more dye than a flattened bristle head of the same width. The colour marking was very obvious at 48 hours, prior to jointing (Fig.18). The joints were carefully inspected for green contamination by both Assessors A and B. A very small amount of contamination was detected in only one joint (the striploin, Fig.19), receiving a score of 1-2 from both assessors (independently). All other joints received a score of 1.

The conclusions from this task are (1) marking the VC by cutting a groove with a pneumatic angle grinder is a workable method that has several advantages. Marking the spinal canal with meat marking pencils provides only a weak visual signal and is unacceptable but the green dye, if carefully applied so that it is confined to the canal, provides a strong signal with minimal contamination of meat.

To prevent/reduce any possible cross-contamination of sides by pathogens/infective material, any equipment that comes into contact with carcass tissues should be immersed in a sterilizer after completion of marking a side. This would apply to any brushes used as well as a cutting disc. It would also be advantageous to have a paint delivery system that precludes the brush being repeatedly immersed in a reservoir of dye. These points should be considered by the relevant authorities.

Table 1. Ratings for colour identity and colour difference between beef carcass VCs dyed blue and

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Carcass (method)	Side	Immediately post marking			48 hours			5 d			
		Assessor			Assessor			Asse			
		A	B	Mean	A	B	Mean	A	I		
1 (brush)	1.1 (Blue)	5	2-3	3.5-4*				5	5		
	1.2 (Purple)	2**	4	3				1***	4		
	Comparison	5	5	5				5	4		
2 (roller)	2.1 (Blue)				5	3	4	5	4		
	2.2 (Purple)				3	4	3.5	2	3		
	Comparison				5	5	5	5	5		
3 (brush)	3.1 (Blue)	5	5	5	5	3	4	5	4		
	3.2 (Purple)	3	4	3.5	3	4	3.5	2	3		
	Comparison	5	5	5	5	5	5	5	5		

* Not obviously different from green ('turquoise-like')

** 'Could be black'

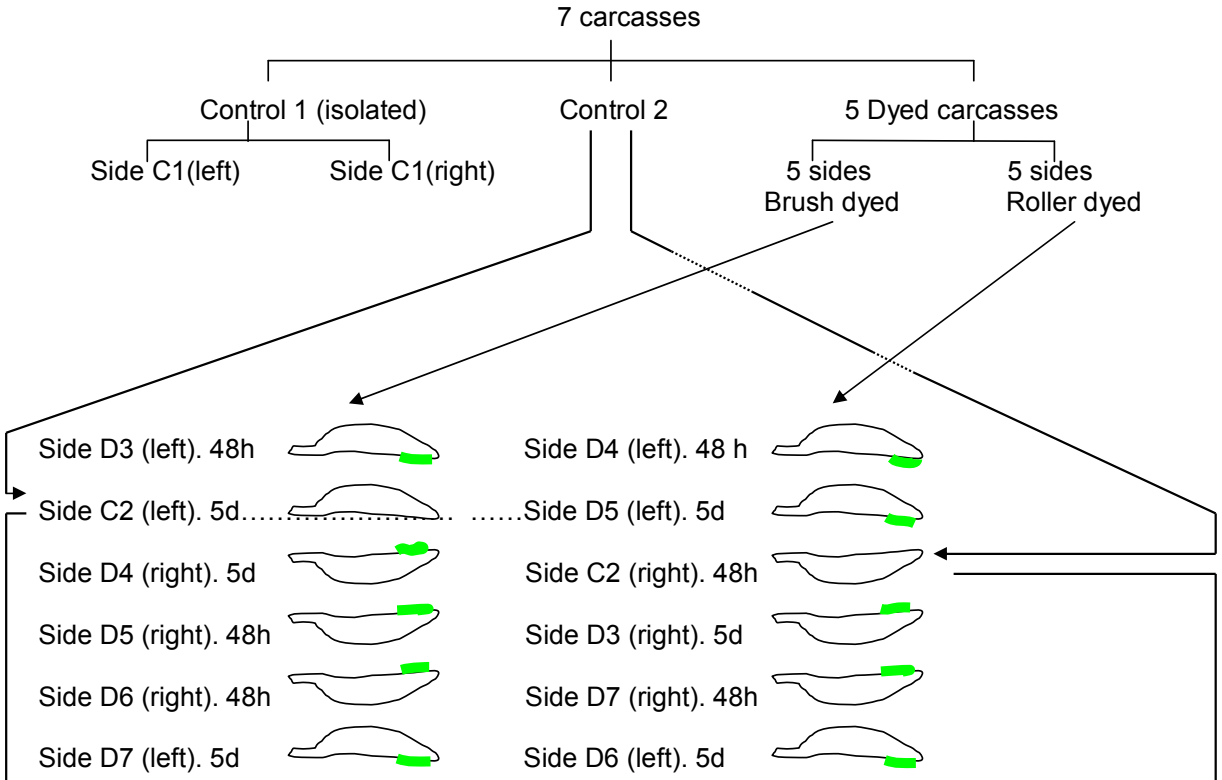
*** 'Looked even blacker than previously

Table 2. Ratings for colour identity and colour difference between beef carcass VCs dyed blue and joints

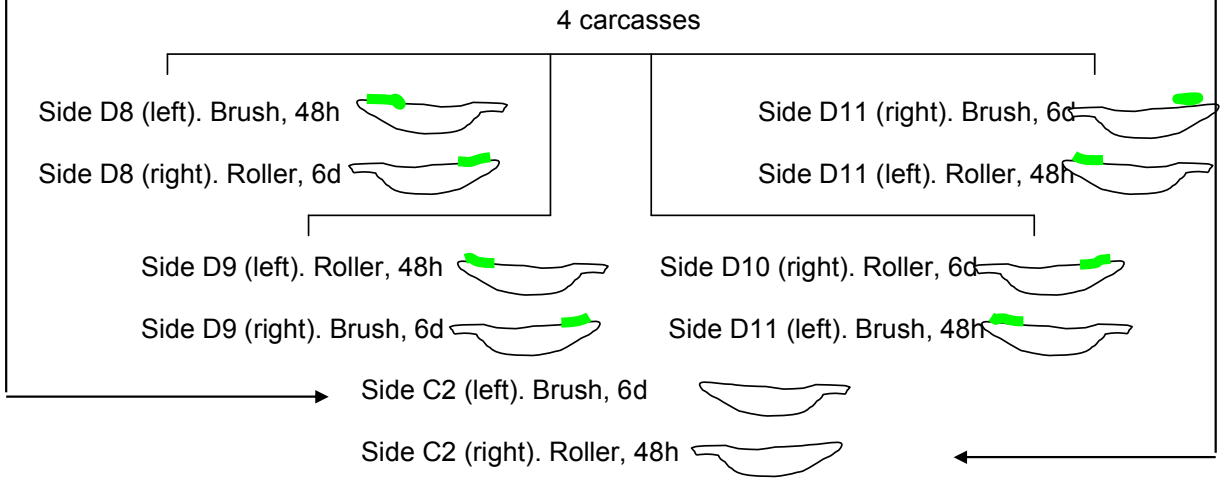
	Assessor C			Assessor D					
	Colour identity		Comparison	Colour identity		Comparison	C		
	Side 1.1 (Blue)	Side 1.2 (Purple)		Side 1.1 (Blue)	Side 1.2 (Purple)		Side (Blu		
Neck	3	2	5	5	3	4	5		
Chuck	3	2	5	5	1	4	5		
Foreribs	3	2	5	5	1	4	5		
Sirloin	3	2	5	5	3	4	5		
Rump	3	2	5	5	2	4	5		
Mean	3	2	5	5	2	4	5		

Fig. 3. Experimental plan to execute Tasks 02 and 03

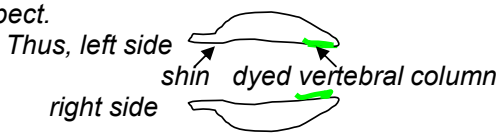
Task 02



Task 03



The symbols represent cross-sections through a carcass side in the forequarter, viewed from the caudal (posterior) aspect.



C = control; D = dyed
n, 1-11 = carcass number

Table 3. Ratings for colour identity (black numerals) and degree of cross contamination (red numerals) of green dye between beef carcass sides

		Immediately post marking		48h		5 days	
Isolated controls							
Side C1L		None		None		None	
Side C1R		None		None		None	
Batch 1 (brush dyed)							
Assessor		**A**	**B**	**A**	**B**	**A**	**B**
Side D3L		5	5	5	5	5	4
Side C2L	Lateral	3-4	4	4	3	3	3
	Medial	2	2	2	2	2	2
Side D4R	Lateral	4	3	4	3	4	3
	Medial	5	5	5	5	5	4
Side D5R	Lateral	4	3	4	3	4	3-4
	Medial	5	5	5	5	5	3
Side D6R		5	5	5	5	5	4
Side D7L	Medial	5	5	5	5	5	4
	Hands	2	2	3	2		
Batch 2 (roller dyed)							
Side D4L		5	5	4	5	5	4
Side D5L	Lateral	3	3	3	3	3	3
	Medial	5	5	4	5	5	4
Side C2R	Lateral	3	2	3	3	3	2
	Medial	1	1-2	2	2	2	2
Side D3R	Lateral	4	4	4	4	4	4
	Medial	5	5	5	5	5	4
Side D7R		5	5	5	5	5	5
Side D6L	Medial	5	5	5	5	5	4
	Hands	3	2	2	1-2		

Table 4. Cross contamination of joints by green dye on VC

Carcass	514 (brush)		516 (roller)		518 (brush)		520 (roller)	
Time of boning	48 hours				6 days			
Joint	Assessor		Assessor		Assessor		Assessor	
	A	B	A	B	A	B	A	B
Neck	1	1	3	3	1	1	2-3	2
Clod	1	1	1	1	1-2	1-2	2	1-2
Chuck	2	2	2	1-2	3	3	1-2	2-3
Leg–o-Mutton	1	1	1-2	1-2	1-2	1-2	2	2
Brisket	1	1	1	1	2	1-2	1-2	1-2
Shin	1	1	1	1	1-2	1-2	1	1
4-rib	2	2	1-2	1-2	3	2-3	2	1-2
Leg	1	1	1	1	1-2	1-2	1	1
Thin flank	2	2	1-2	1-2	1-2	1-2	1-2	1-2
Topside	1-2	1-2	1-2	1-2	2	1-2	1	1
Silverside	2	2-3	2	1-2	1-2	1-2	1-2	1-2
Fillet	3	2-3	3	2	3	2	3	3
Thick flank	2	1-2	2	2	2	1-2	1-2	2
Striploin	2	1-2	2	1-2	2	2-3	2	2-3
Rump	2	1-2	2-3	2	2-3	3	2-3	3-4

Scores 1-5 where 1=no visible dye.2=a few small specks, 3=several specks or a larger area of smeared dye, 4=large areas of speckling or smearing, 5=contamination over whole surface

Table 5. Assessments of clarity of mark in intact sides and in bone-in primal joints. Meat marking pencils in spinal canal and cut groove

			Consensus score			Primal joints*		
			Groove	Blue pencil	Brown pencil	Assessor 1	Assessor 2	Assessor 3
Carcass 1	Right side	Immediately	4 - 5					
		48h	4			4 (2 for neck). Quite apparent but could be deeper	4 (3 for neck). Obvious if know what to look for	5 (2 for neck). Obvious mark
	Left side	Immediately		4 - 5				
		48h		2		2. Looks like melanosis or SRM dye splash	-	2. Could be dye , not sure if mark
Carcass 2	Right side	Immediately	4 - 5					
		48h	3 - 4					
		6d	3 - 4			2. Not really obvious	2.	
	Left side	Immediately			1			
		48h			1			
		6d			1	1. No mark	1. Nothing apparent	

* Score, followed by comment (if given)

Appendix
Trials with the orange dye (MM Orange)

The orange dye was supplied by the manufacture in 12 shades, ranging from 1 = lightest to 12 = darkest. These dyes were applied by brush to vertebrae cervical 7 through to thoracic 11 in one carcass side. Colour identity was assessed as in Task 01, immediately after marking, at 48 hours or at 5 days. Solutions 1 and 2 had scores of 2 or below at all time points as the colour was similar to yellow. The highest scores (3) were given to solutions 3 and 4 at all time points. Solutions 5 and 6 received scores of 2 or 2-3 as these were similar to red. Solutions 7 – 12 received scores of 1 because they appeared to be red. Solution 4 was selected for further study.

One carcass was used to assess the properties of MM Orange and to determine if this colour could be readily differentiated from the yellow. The VC in one side was stained orange and the other side was stained yellow, the dyes being applied by the same brush specified in Task 01, after carcass washing. The VCs were examined at three time points after marking – immediately, after 48 hours and after 5 days in a chill room operating at 2 ± 2^0C. At these times two assessors (Assessor A and Assessor B) used 5-point scales to independently score individual VCs for colour identity (score 1=poor to 5=good) and to compare the two stained VCs from the same carcass (1=no apparent difference to 5=no possibility of confusion). The results are shown in Table A1.

Table A2. Ratings for colour identity and colour difference between beef carcass VCs dyed orange and yellow

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Carcass	Side	Immediately post marking			48 hours			5 days			Overall mean
		Assessor			Assessor			Assessor			
		A	B	Mean	A	B	Mean	A	B	Mean	
1 (brush)	A1 (Orange)	3*	3	3	2	2	2	3	2	2.5	2.5
	A2 (Yellow)	3**	4	3.5	3	3	3	3	2	2.5	3
	Comparison	2	4	3	1	2	1.5	1	2	1.5	2

'Looked yellow in sacral region'
'Looked orange in cervical region'

There was little to choose between the colour identity scores for the orange and yellow dyes, with overall scores of 2.5 and 3, respectively. The comments given by Assessor A suggest that these two colours are not distinct and the scores for comparison were consistently lower for Assessor A than Assessor B. But, overall,

the comparison scores were low (2), indicating that discrimination between these colours was poor.

These sides were then cut into primal joints and three additional persons (members of the DFAS slaughter and dissection teams, two (Assessors D and E) being the same as those in Task 01; Assessor F was not previously involved) were asked to score the joints for colour identity and to compare the VCs in the same joints from the two sides using the same scales as in Task 01. The results in Table A2 reflect those obtained from the assessment of VCs in carcass sides, namely that the colour identity scores are lower for the orange dye than for the yellow, but the overall means for the joints were lower than those for the sides. There was some indication of variation between joints with two of the assessors (E and F) scoring both colours identities highest in the rump whilst Assessor D scored the colours in the rump as highly as those in the sirloin. The reason for this is probably the whiter background colour of the fused sacral bones that appear to be less well supplied by blood than other vertebrae. None of the assessors was able to clearly distinguish between the orange and the yellow dyed VCs.

Table A2. Ratings for colour identity and colour difference between beef carcass VCs dyed orange primal joints

	Assessor D			Assessor E					
	Colour identity		Comparison	Colour identity		Comparison	C		
	Side 1.1 (Orange)	Side 1.2 (Yellow)		Side 1.1 (Orange)	Side 1.2 (Yellow)		Side (Oran		
Neck	1	2	1	1	1	1	1		
Chuck	1	2	1	1	1	1	2		
Foreribs	1	2	1	1	1	1	2		
Sirloin	1	3	1	1	2	1	1		
Rump	1	3	1	3	3	3	3		
Mean	1	2.4	1	1.4	1.6	1.4	1.8		

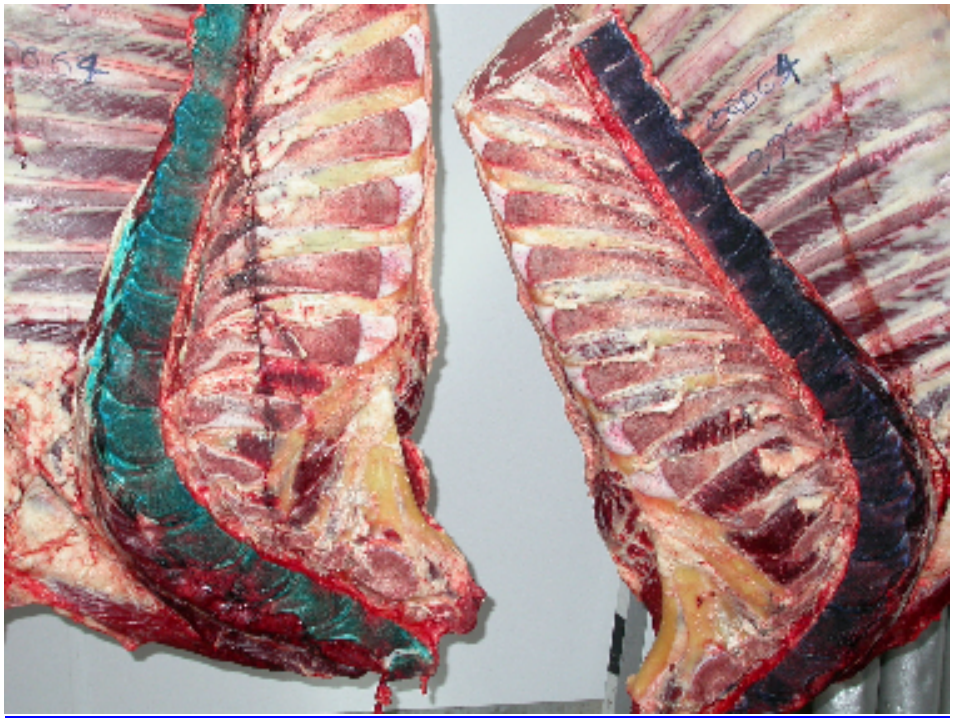

Figure 1. VCs in two forequarters stained with blue (left) and purple (right) dyes

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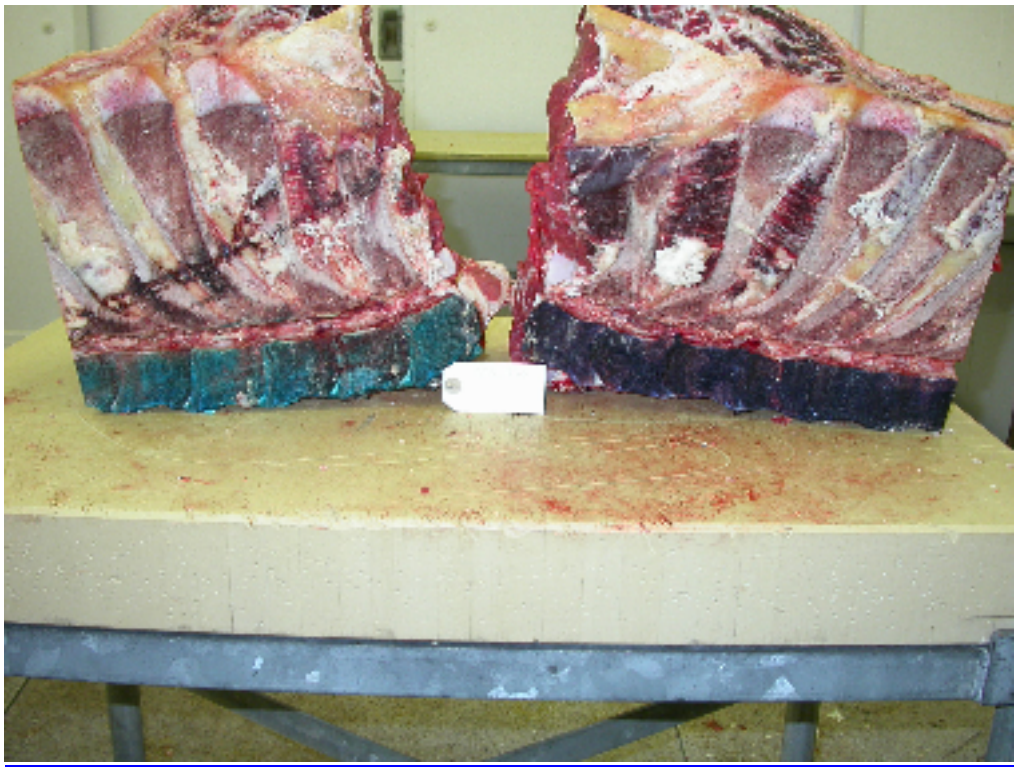

Figure 2. The chuck joint from two carcass sides whose VCs were stained with blue (left) and purple (right) dyes

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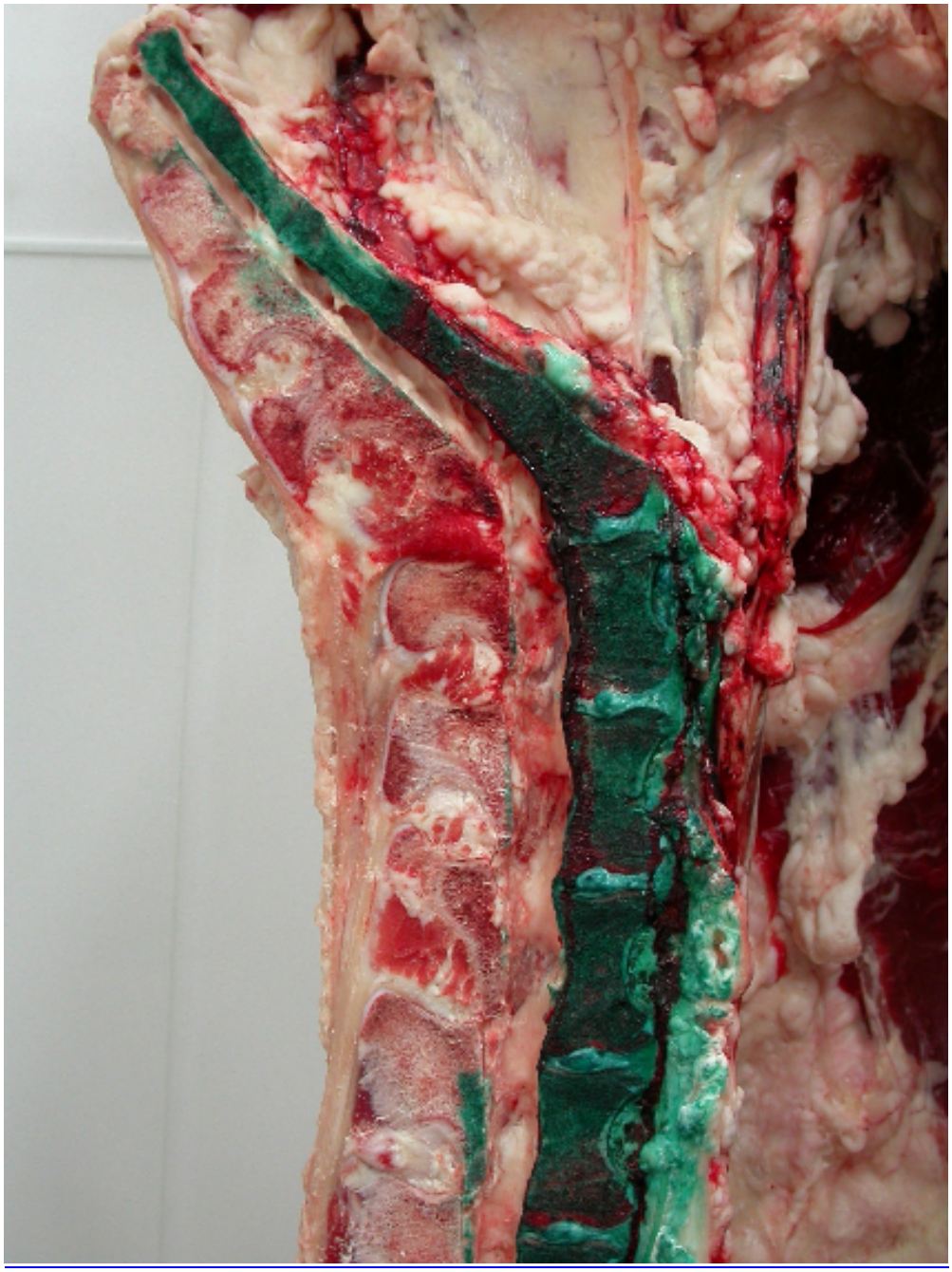

Figure 4. Hindquarter VC stained with the green dye

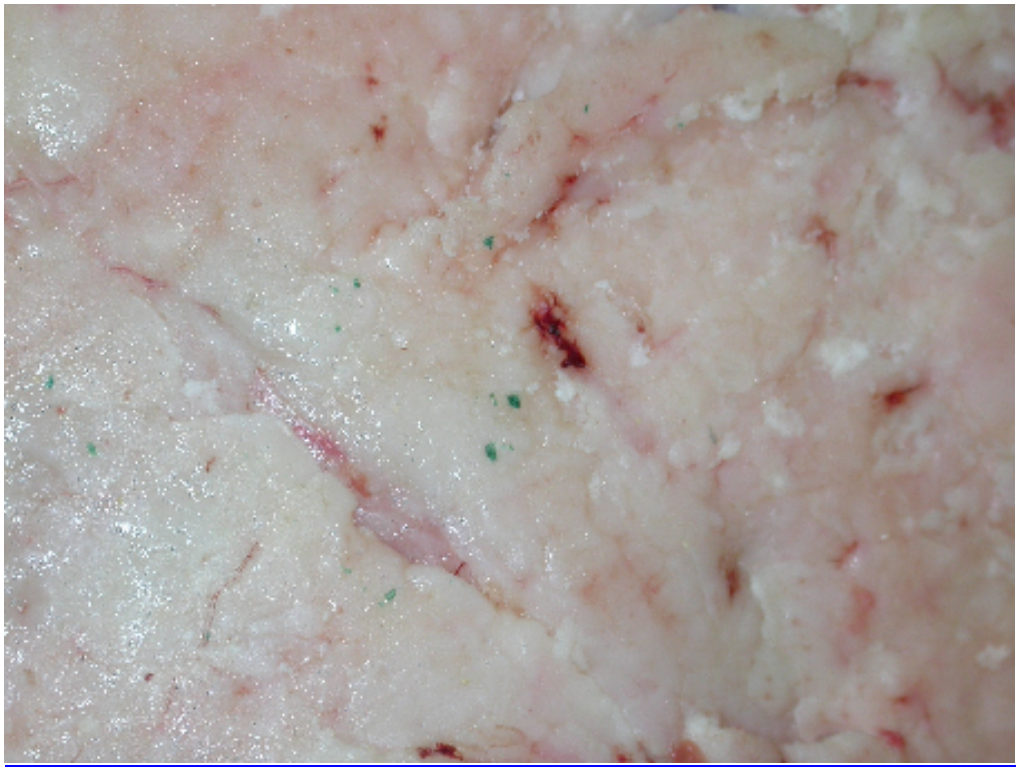

Figure 5. Specks of green dyed material on the surface fat of the striploin joint following carcass jointing

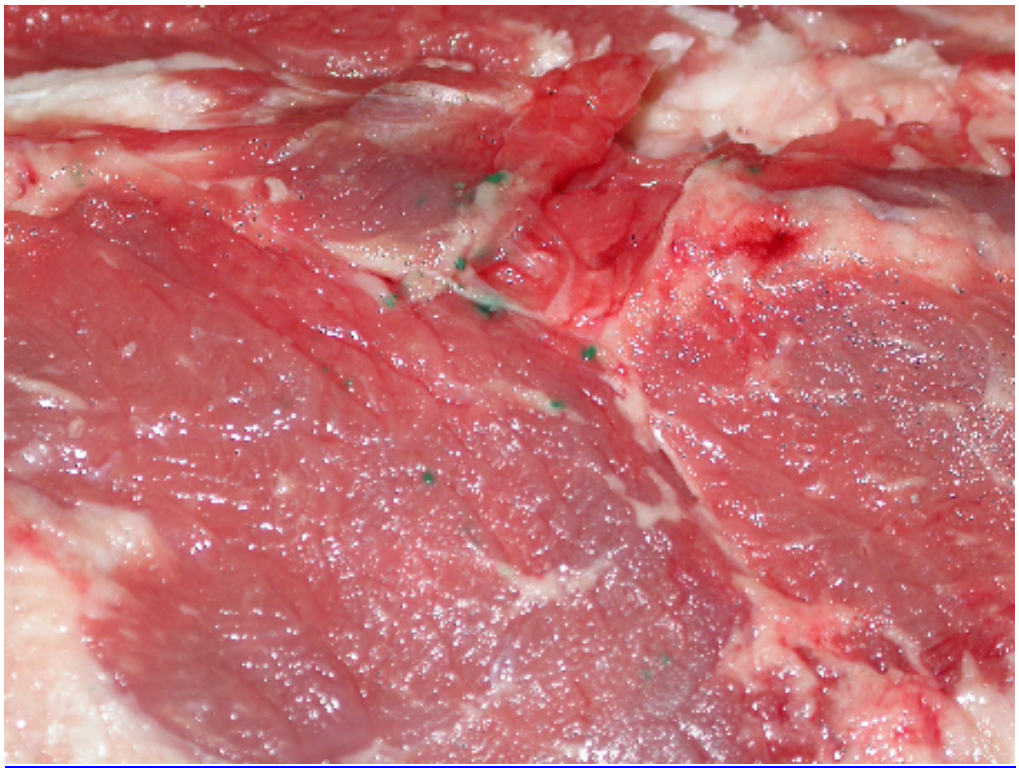

Figure 6. Specks of green dyed material on the muscle in the leg of mutton cut following carcass jointing

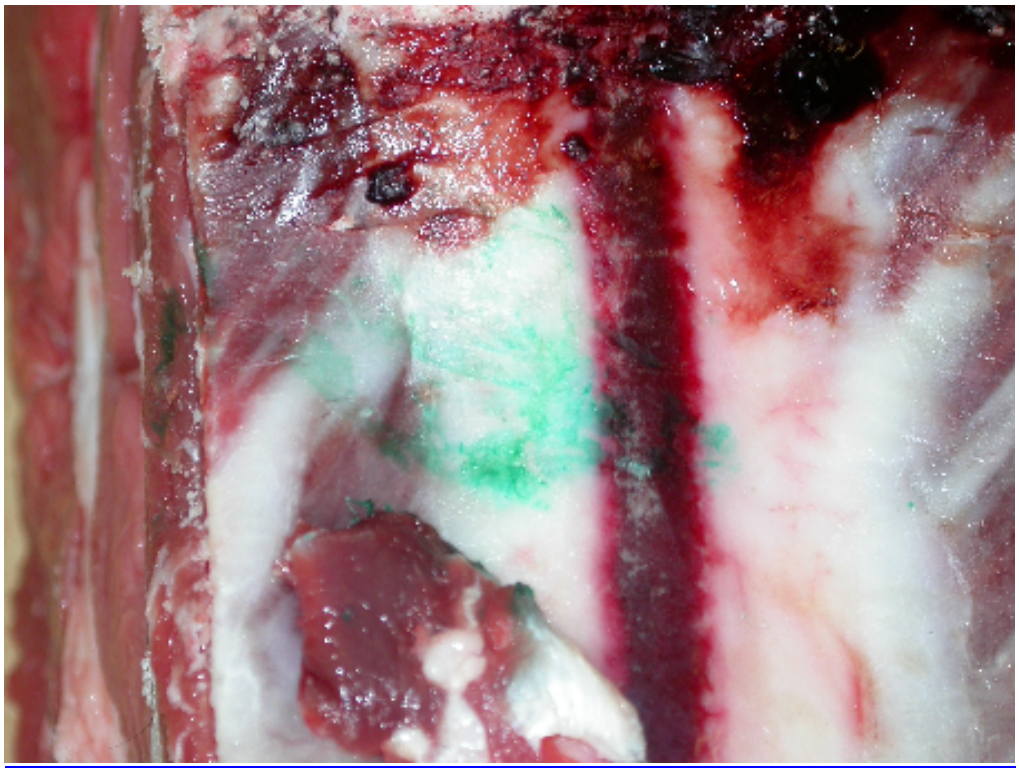

Figure 7. Smear of green dye on the fat in the chuck joint after carcass jointing

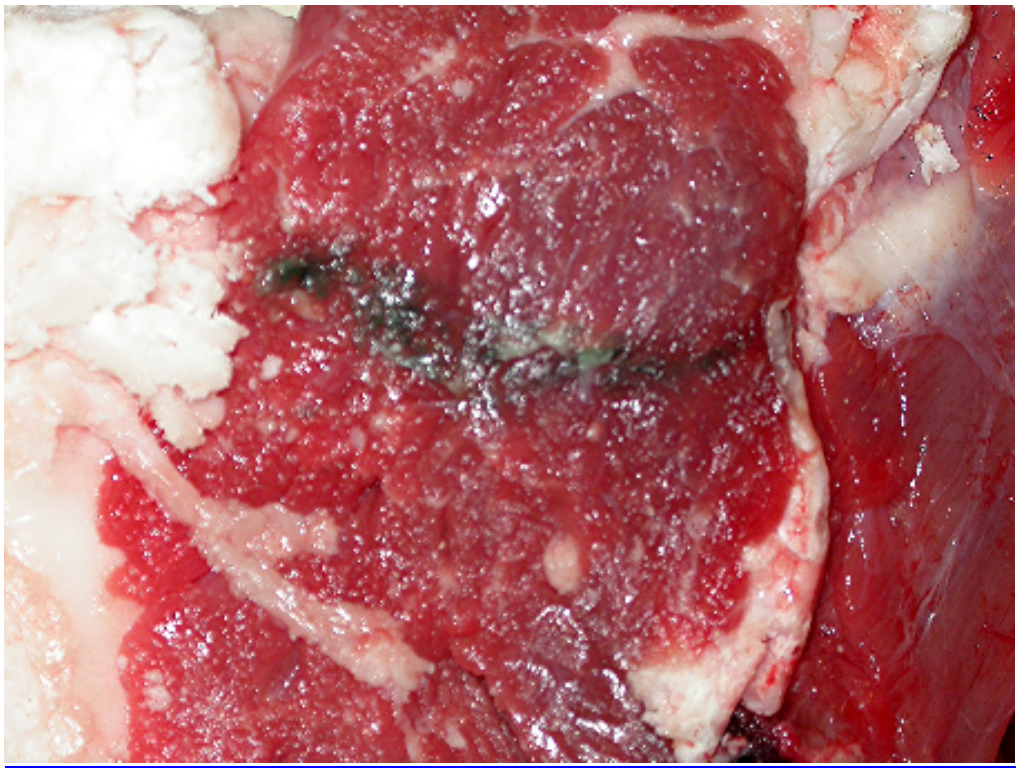

Figure 8. Smear of green dye on the cut muscle surface of the topside joint following carcass jointing

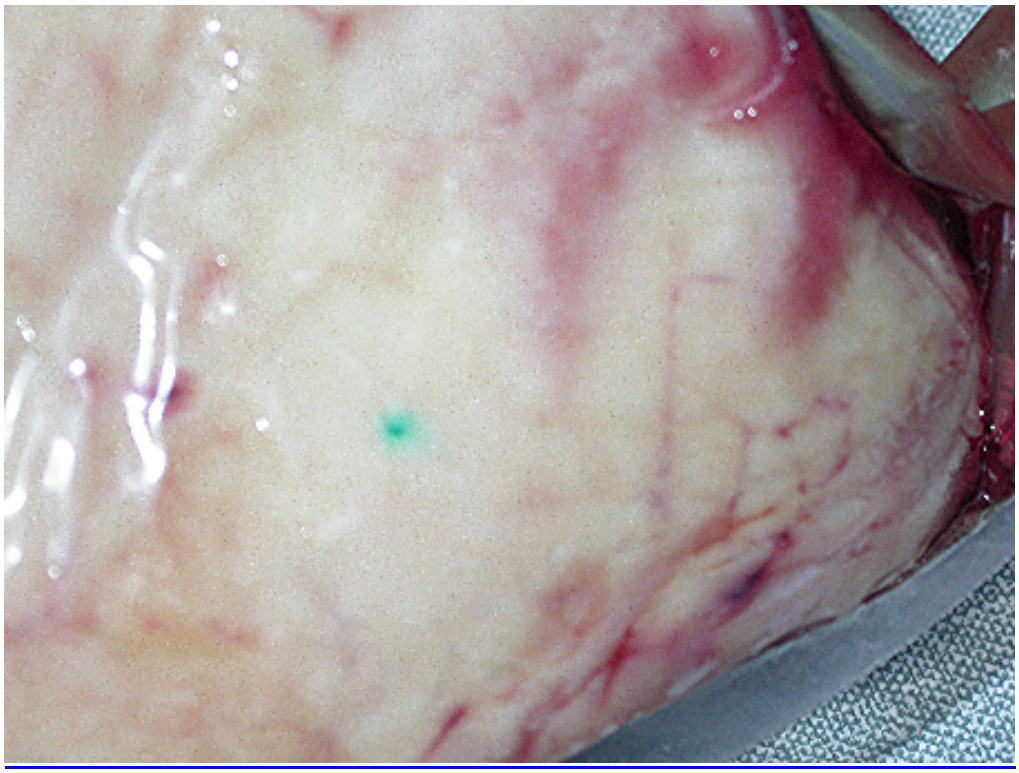

Figure 9. Green dye contamination of a vacuum-packed primal showing the 'halo effect'

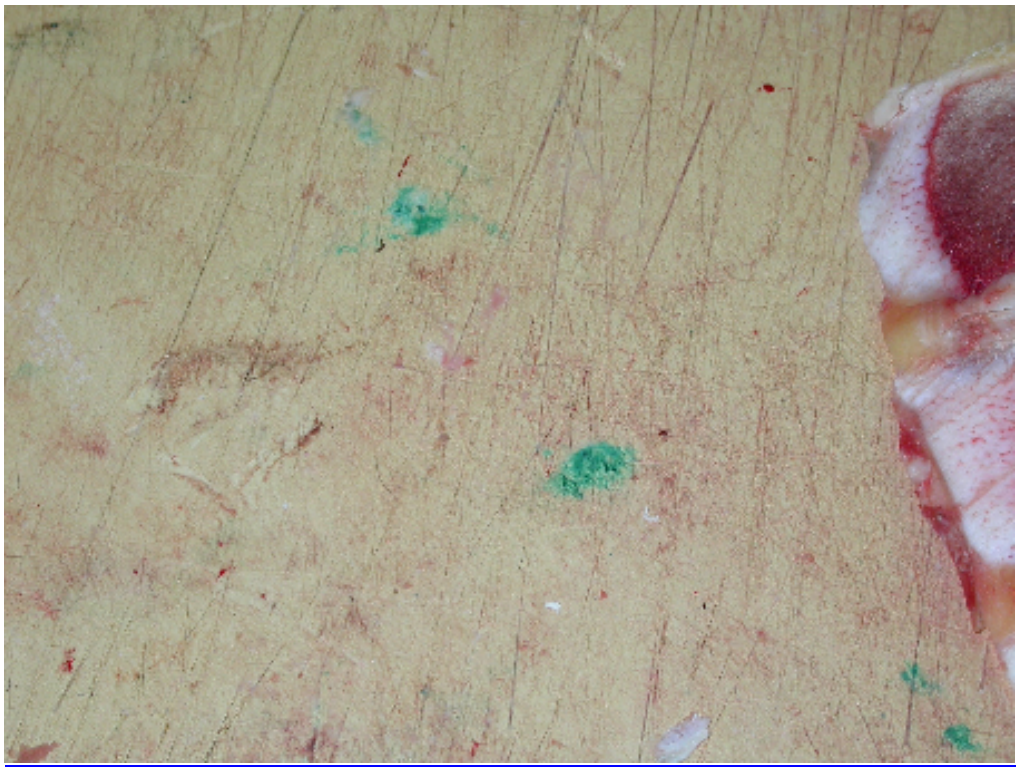

Figure 10. Green dye transferred to the cutting table during carcass jointing.

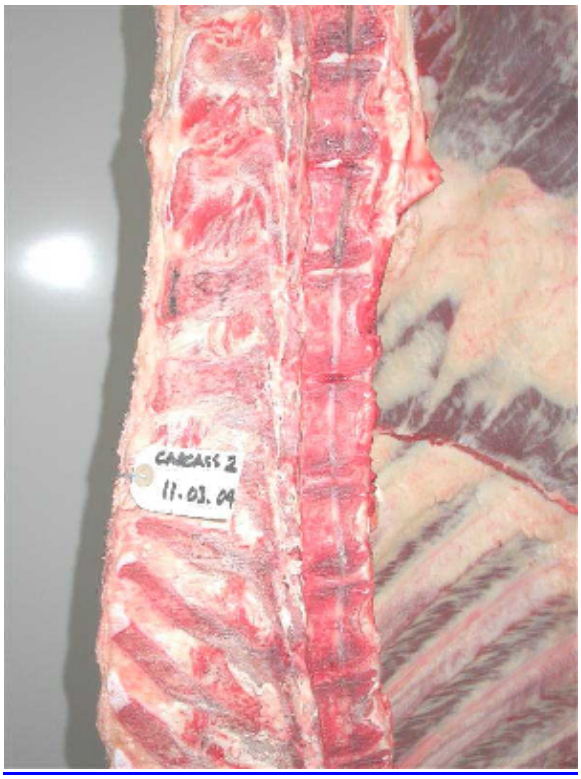

Figure 11. VC marked with angle grinder, 48h post marking

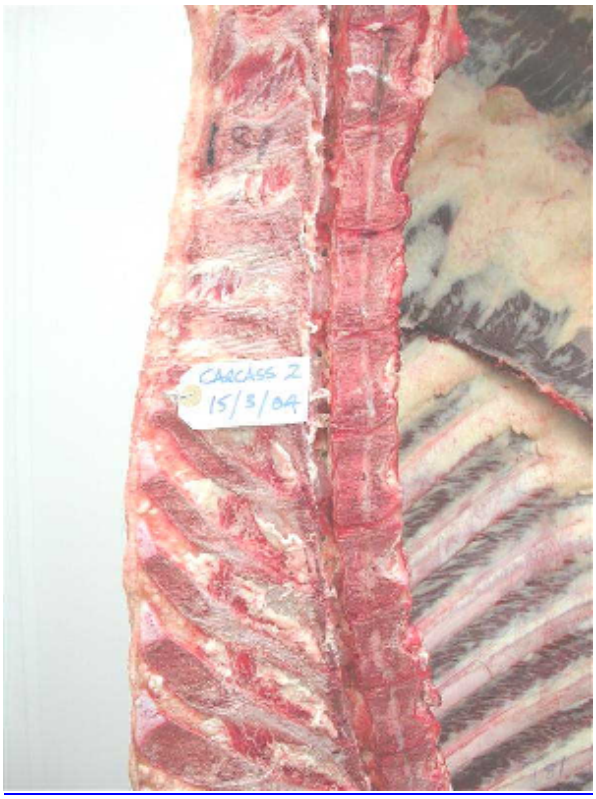

Figure 12. VC marked with angle grinder, 6d post marking

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Figure 13. VC marked with 'masonry disc' in pneumatic angle grinder, 48h post-marking

Figure 14. VC marked with 'metal disc' in pneumatic angle grinder, 48h post-marking

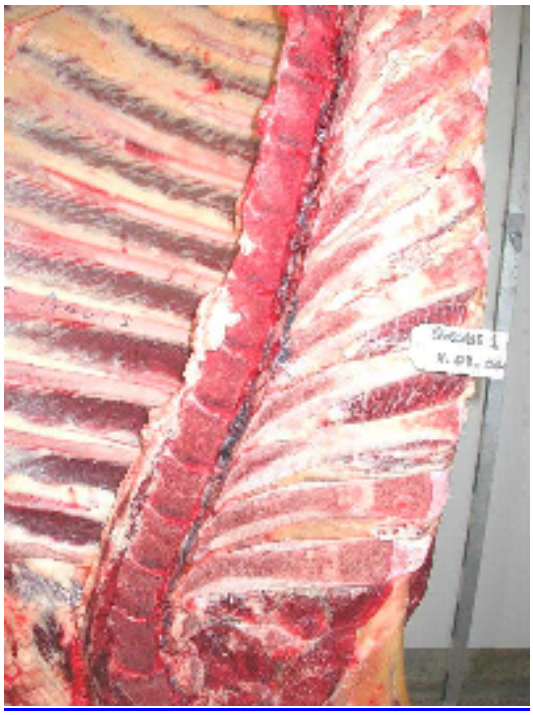

Figure 15. Spinal canal marked with blue meat-marking pencil, 48h post-marking

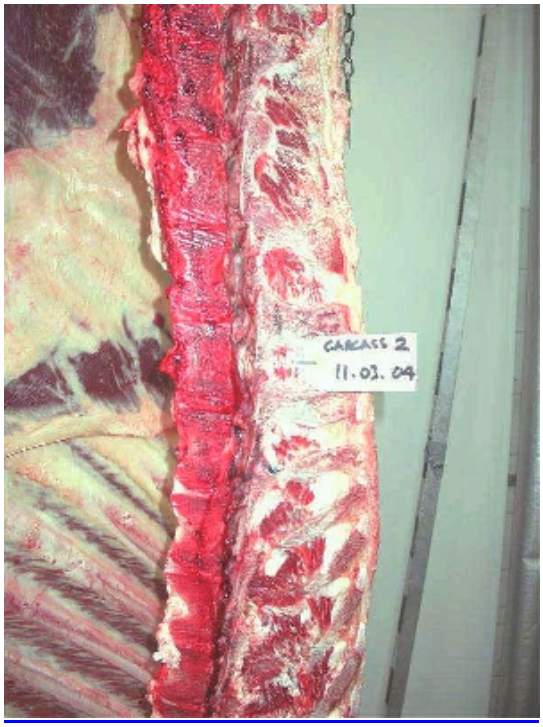

Figure 16. Spinal canal marked with brown meat-marking pencil, 48h post-marking

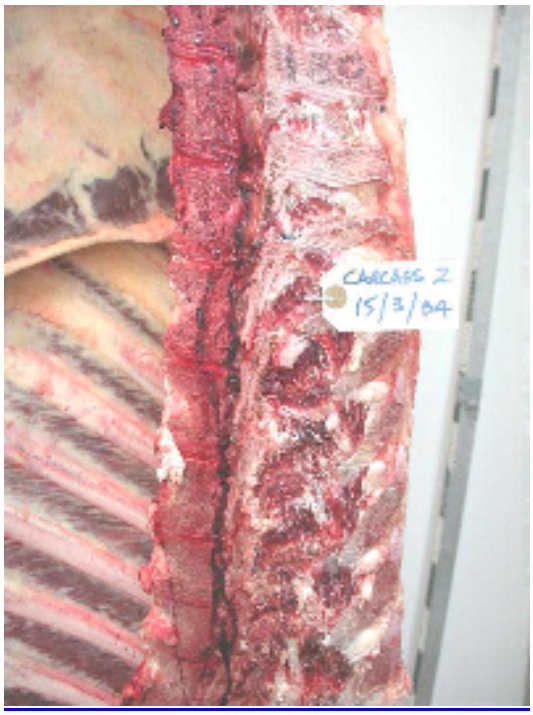

Figure 17.Spinal canal marked with brown meat marking pencil, 6d post-marking

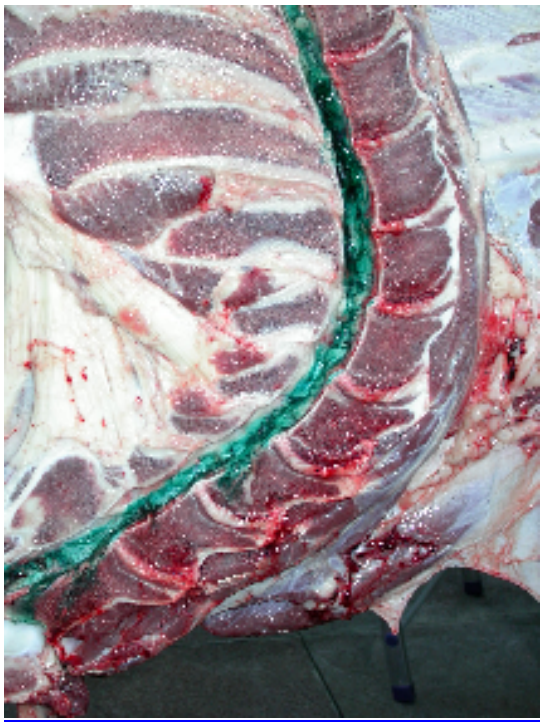

Figure 18. Spinal canal marked with green dye, 48h post-marking

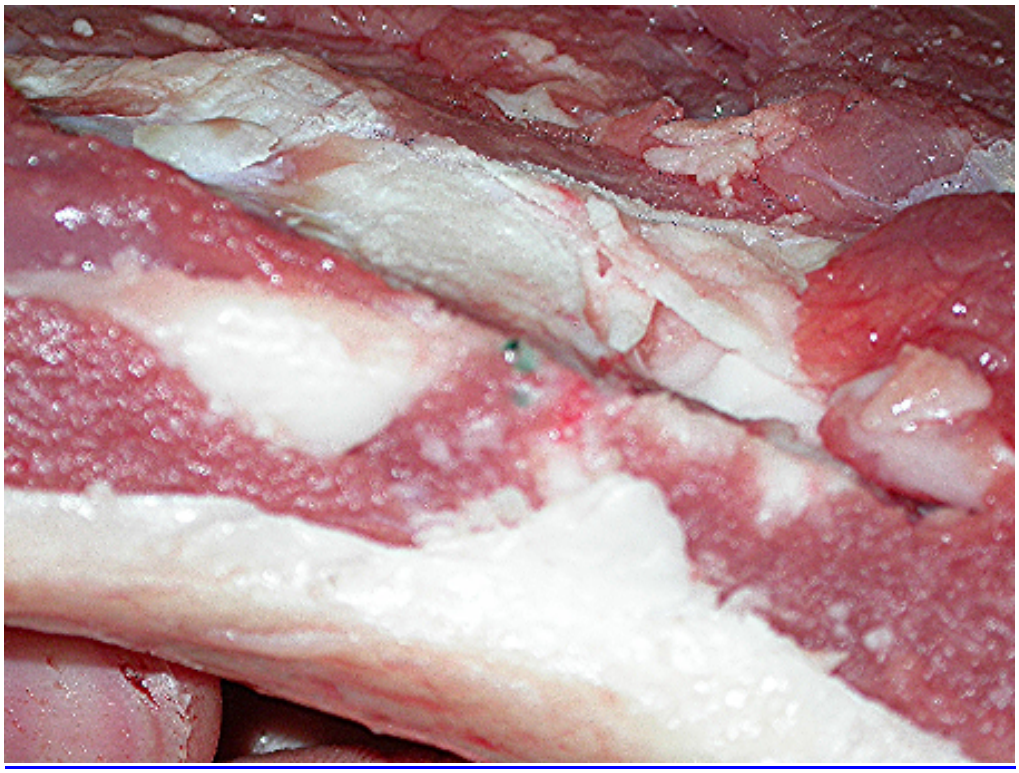

Figure 19. Specks of green dye found on the striploin joint after carcass jointing. Spinal canal stained with green dye