

EFFECTS OF STUNNING METHOD AND TIME INTERVAL FROM STUNNING TO EXSANGUINATION ON BLOOD SPLASHING IN PORK¹

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Summary

Two studies were designed to test the effects of stunning method and time interval between stunning and exsanguination on blood splashing in pork muscle. In study I, 82 market weight barrows and gilts were assigned randomly to one of two treatments using captive bolt (CB) stunning with either a short (S; 18.5 ± 11.1 s) or a delayed (D; 144.7 ± 36.8 s) time interval to exsanguination. More ($P < .05$) blood splashing occurred in the ham, loin and shoulder of the D group than in the S group. In study II, 48 barrows and gilts were assigned randomly to one of four treatment combinations using either CB or electric (E) stunning with time intervals of either S (8.7 ± 3.5 s) or D (96.0 ± 19.1 s) before exsanguination. The CB groups had longer kicking times and softer, lighter colored gluteus medius muscles ($P < .05$) than did the E groups. Sex or side of carcass did not affect ($P > .05$) blood splashing. Carcasses in the CB-D group had more ($P < .05$) blood splashing in the diaphragm, fresh ham face and cured ham than in those muscles from the other treatment groups. Blood splashing in the diaphragm, ham face and cured ham were similar ($P > .05$) for the CB-S, E-S and E-D groups. The gluteus medius muscle of pigs in the CB-D group had more ($P < .05$) blood splashing than did the other muscles from pigs in this group. Blood splashing in the diaphragm was correlated with blood splashing in the ham face (.69), cured ham (.69), gluteus medius (.71), gluteus accessorius (.48) and obturatorius internus (.54).

(Key Words: Blood Splashing, Pork, Exsanguination, Captive Bolt Stunning, Electrical Stunning.)

Introduction

Blood splashing is an important quality factor in pork, especially for small meat processors (Anonymous, 1981). Blood splashing occurs when small capillaries in the muscle rupture, causing a pinpoint hemorrhage (Lawrie, 1974). These hemorrhages may be related to increased blood pressure (Shaw et al., 1971), muscular contractions and blood catecholamine levels (van der Wal, 1971, 1978a).

Blood splashing can occur in pork muscle regardless of the type of animal immobilization method used (van der Wal, 1978a); however, stunning with a captive bolt produces a higher incidence of blood splashing than electrical or carbon dioxide immobilization. Increasing the time interval between stunning and exsanguination also can increase the amount of blood splashing in pork (Bloomquist, 1958; van der Wal, 1978a).

The purpose of this study was to observe the combined effects of stunning method and the time interval between stunning and exsanguination on blood splashing in pork.

Experimental Procedure

Study I. Eighty-two market weight barrows and gilts were assigned randomly to one of two treatments using captive bolt (CB) stunning in combination with either a short (S) time interval of 18.5 s ($SD \pm 11.1$) to reduce the degree of blood splashing (van der Wal, 1978a) or a delayed (D) time interval of 144.7 s ($SD \pm 36.8$) to exsanguination to maximize the chance for blood splashing (van der Wal, 1978b). A Schermer model ME³ captive bolt stunner loaded with a number 17 load was placed on the pig's forehead to penetrate the anterior portion of the brain to stun the pigs. Pigs in the S group were stuck and bled in the prone position before they were shackled and hoisted and pigs in the D group were shackled and hoisted before exsanguination. The degree of blood splashing was scored (1 = none or

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TABLE 1. EFFECT OF SEX AND SIDE OF CARCASS ON BLOOD SPLASHING IN THE HAM OF PIGS FOR STUDIES I AND II

Study-factor	Barrows	Gilts
Study I ^{ab}		
Captive bolt-short	1.1	1.1
Captive bolt-delayed	1.8	1.8
Study II ^{ac}		
Captive bolt-short	1.3	2.3
Captive bolt-delayed	10.3	13.0
Electric-short	.7	.6
Electric-delayed	.8	.7
Study II ^{ad}		
	Left side	Right side
Captive bolt-short	.6	1.0
Captive bolt-delayed	6.9	5.2
Electric-short	.2	.5
Electric-delayed	.4	1.5

^aMeans within a row were not different ($P>.05$).

^bMeans for ham blood splashing scores: (1 = none or practically none, 2 = slight, 3 = moderate, 4 = severe).

^cMeans for number of blood splashes in the muscles of the left and right fresh ham faces.

^dMeans for number of blood splashes in the muscles of the fresh ham face.

practically none, 2 = slight, 3 = moderate, 4 = severe) in the muscles of the wholesale shoulder, loin and ham independently by two of the authors when the carcasses were fabricated at 48 to 72 h postmortem.

Study II. Forty-eight barrows and gilts were assigned randomly to one of four treatments involving all combinations of CB or electrical (E) stunning with either a S or D time interval to exsanguination. Average time intervals (\pm SD) from stunning to exsanguination were CB-S, 8.4 ± 2.8 s; CB-D, 91.3 ± 3.1 s; E-S, 9.0 ± 4.1 s and E-D, 100.7 ± 26.6 s. Captive bolt stunning was done with a Supercash Mark 2⁴ captive bolt pistol using a two grain charge. The pistol was placed on the forehead to penetrate the anterior portion of the brain. Electrical stunning was with a Cervin model SSR⁵ electrical stunner at a setting of 560 V with the

electrodes placed across the anterior cervical region for about 2 s.

After stunning, pigs were stuck and bled in the prone position before they were shackled and hoisted by the right hind leg. The time between stunning and cessation of violent kicking was recorded. Carcass data and diaphragm blood splashing scores (1 = none or practically none, 2 = slight, 3 = moderate, 4 = severe) were collected after chilling for 24 h at 3 C. The number of blood splashes in the muscles of both the right and left fresh ham face was counted when the carcasses were fabricated. Gluteus medius muscle color and firmness were scored using a five point scale of 1 = extremely pale and soft; 5 = very dark and dry (Anonymous, 1963). Blood splashes were counted again after the boneless hams were cured and cut into halves.

Data were analyzed by analysis of variance and General Linear Modeling and means were separated by Duncan's multiple range test using the Statistical Analysis System package (SAS, 1979).

Results and Discussion

Study I. Barrows and gilts did not differ ($P>.05$) in the degree of blood splashing in the ham (table 1). Blood splashing scores (table 2) for the ham, loin and shoulder muscles of pigs from the D group were greater ($P<.05$) than those for pigs from the S group.

Study II. Hot carcass weight (70.8 kg), dressing percentage (72.5%), 10th rib fat depth (2.0 cm), loin eye area (30.3 cm²) and percentage muscle (55.5%) were not affected by treatment ($P>.05$). Captive bolt stunned pigs

TABLE 2. BLOOD SPLASHING SCORES^a OF THE HAM, LOIN AND SHOULDER FOR SHORT AND DELAYED TIME INTERVALS FROM STUNNING TO EXSANGUINATION IN STUDY I

Locations	Short	Delayed
Ham	1.1 ^b	1.8 ^c
Loin	1.0 ^b	1.5 ^c
Shoulder	1.0 ^b	1.4 ^c

^a1 = none or practically none, 2 = slight, 3 = moderate, 4 = severe.

^{b,c}Means within a row with a different superscript differ ($P<.05$).

⁴ Accles and Shelvoke LTD. Birmingham, England.

⁵ Cervin Electric MFG. Co. Division of Cervin Electronics Co. Minneapolis, MN.

TABLE 3. KICKING TIMES AND MUSCLE QUALITY SCORES FOR STUNNING TREATMENTS IN STUDY II

Factor	Captive bolt		Electric
	Short	Delayed	
Kicking time, s	80.3 ^c	42.7 ^d	
Gluteus medius color ^a	2.4 ^c	3.0 ^d	
Gluteus medius firmness ^b	2.5 ^c	2.9 ^d	

^a1 = pale, 3 = pinkish gray, 5 = dark.

^b1 = soft, 3 = firm, 5 = very firm.

^{c,d}Means within a row with a different superscript differ ($P < .05$).

(table 3) had longer ($P < .05$) kicking times after stunning and softer, lighter colored ($P < .05$) gluteus medius muscle than did pigs stunned electrically.

The number of blood splashes in the ham face (table 1) of barrows and gilts was not different ($P > .05$), which agrees with results of study I. Also, there were no differences ($P > .05$) for blood splashing in right or left sides of carcass (table 1) even though all pigs were shackled by the right leg. Calkins et al. (1980) indicated more blood splashing in the left side of the carcasses, but they did not state which leg was shackled.

Pigs from the CB-D group had more ($P < .05$) blood splashes in the fresh ham face and cured ham and had higher ($P < .05$) blood splashing scores for the diaphragm (table 4) than did pigs in the other three treatments. Data from both studies indicate more blood splashing will occur with longer time intervals from stunning to exsanguination when pigs are immobilized using a captive bolt. However, an increased time

interval from stunning to exsanguination did not affect ($P > .05$) the amount of blood splashing in the ham of electrically stunned pigs (E-S and E-D). Others (Bloomquist, 1958; van der Wal, 1978a) have reported an increased incidence of blood splashing with an increased time interval between stunning and exsanguination for either electrical or captive bolt stunning; however, their electrical stunning methods involved lower voltages applied for a longer time than in our study.

van der Wal (1978a) stated that captive bolt stunning produced a higher incidence of blood splashing than electrical or carbon dioxide stunning methods. Pigs in CB-D group did have more ($P < .05$) blood splashing (table 4) in the ham and diaphragm muscles than did those stunned electrically. However, the number of blood splashes in the ham face and cured ham as well as blood splashing scores for the diaphragm muscle were similar ($P < .05$) for CB-S and electrically stunned pigs.

Individual skeletal muscles may differ in their sensitivity for blood splashing. Although the degree of blood splashing was similar ($P > .05$) in all muscles measured from pigs in the CB-S, E-S and E-D groups (table 5), the degree of blood splashing in muscles from pigs in the CB-D group was different ($P < .05$). The gluteus medius muscle from pigs in the CB-D group had more ($P < .05$) blood splashing than any other muscle from pigs in this group. Among pigs in the CB-D group the obturator internus muscle had more ($P < .05$) blood splashing than the gluteus profundus, tensor fasciae latae, psoas major and longissimus muscles, and the gluteus accessorius muscle had more ($P < .05$) blood splashing than the gluteus profundus and longissimus muscles. Stunning method and time interval to exsanguination

TABLE 4. BLOOD SPLASHING NUMBERS IN THE HAM AND DIAPHRAGM SCORES FOR STUNNING METHOD AND STUNNING TO EXSANGUINATION TIME INTERVAL TREATMENTS IN STUDY II

Location	Captive bolt		Electric	
	Short	Delayed	Short	Delayed
Fresh ham face ^a	1.6 ^c	12.1 ^d	.7 ^c	1.9 ^c
Cured ham ^a	.2 ^c	2.2 ^d	.1 ^c	.4 ^c
Diaphragm ^b	1.0 ^c	2.3 ^d	1.1 ^c	1.2 ^c

^aMeans for the number of blood splashes in the left and right sides.

^b1 = none or practically none, 2 = slight, 3 = moderate, 4 = severe.

^{c,d}Means within a row with a different superscript differ ($P < .05$).

TABLE 5. INDIVIDUAL MUSCLE BLOOD SPLASHING NUMBERS FOR STUNNING METHOD AND STUNNING TO EXSANGUINATION TIME INTERVAL TREATMENTS IN STUDY II

Muscle	Captive bolt		Electric	
	Short	Delayed	Short	Delayed
Gluteus accessorius	.0ac	1.3bde	.0ac	.5abc
Gluteus medius	1.1ac	7.3bf	.5ac	.8ac
Obturatorius internus	.1ac	2.1be	.0ac	.5ac
Gluteus profundus	.0ac	.1ac	.0ac	.0ac
Tensor fasciae latae	.1ac	.3acd	.2ac	.1ac
Gluteus superficialis	.3ac	.9acde	.0ac	.0ac
Psoas major	.0ac	.2acd	.0ac	.0ac
Longissimus	.0ac	.0ac	.0ac	.0ac

a,b Means within a row with different superscripts differ ($P < .05$).

c,d,e,f Means within a column with different superscripts differ ($P < .05$).

comparisons for individual muscles indicate the gluteus medius and obturatorius internus muscles in the fresh ham face of pigs in the CB-D group (table 5) had more ($P < .05$) blood splashing than similar muscles in pigs from the other three treatments. Also, carcasses in the CB-D group had more ($P < .05$) blood splashing in the gluteus accessorius than in this muscle in carcasses from the CB-S and E-S groups. The incidence of blood splashing in the gluteus profundus, tensor fasciae latae, gluteus superficialis, psoas major and longissimus muscles did not differ ($P > .05$) for stunning method and time interval to exsanguination. van der Wal (1978b) stated that the sensitivity to blood splashing of different skeletal muscles is not equal and noted the gracilis and quadriceps muscles had a higher incidence of blood splashing while the psoas major, longissimus, semitendinosus and biceps femoris muscles had a lower incidence of blood splashing.

Blood splashing in the diaphragm muscle may provide an indication of the degree of blood splashing in other skeletal muscles. Even though diaphragm blood splashing scores were based on a discrete rating scale, the correlations of blood splashing scores in the diaphragm muscle to blood splashing in the fresh ham face (.69), cured ham (.69), gluteus medius (.71), gluteus accessorius (.48) and obturatorius internus (.54) indicate a positive relationship.

These studies indicate that although captive bolt stunning causes more blood splashing in pork muscle than other stunning methods, the time interval between stunning and exsanguination is critical. Sticking pigs within 10 to 20 s

after stunning with a captive bolt will reduce blood splashing in the muscle and may make this method of stunning comparable with electrical stunning for the degree of muscle blood splashing. Even though skeletal muscles vary in sensitivity to blood splashing, the degree of blood splashing in the diaphragm may indicate the degree of blood splashing in the ham muscles.

Literature Cited

- Anonymous. 1963. Pork quality standards. Special Bull. 9. Wisconsin Agr. Exp. Sta., Madison.
- Anonymous. 1981. A survey report on the problem of pork muscle capillary rupture-blood splattering. *Meat Processing* 20:48.
- Bloomquist, S. M. 1958. Some observations on the electrical stunning of pigs—2. *Food Manufacture* 33:491.
- Calkins, C. R., G. W. Davis, A. B. Cole and D. A. Hutsell. 1980. Incidence of blood splashed hams from hogs subjected to certain antemortem handling methods. *J. Anim. Sci.* 51(Suppl. 1):15.
- Lawrie, R. A. 1974. *Meat Science* (2nd Ed.). Pergamon Press, Oxford.
- SAS. 1979. SAS User's Guide. Statistical Analysis System Institute, Cary, NC.
- Shaw, F. D., J. F. Weidmann and R. I. Baxter. 1971. Vaso-active drugs and the occurrence of intramuscular ecchymotic hemorrhages in the electrically stunned rat. *Res. Vet. Sci.* 12:480.
- van der Wal, P. G. 1971. Stunning, sticking and exsanguination as stress factors in pigs. Proc. 2nd Int. Symp. Condition Meat Quality Pigs, Zeist, Pudoc, Wageningen. p 153.
- van der Wal, P. G. 1978a. Chemical and physiological aspects of pigs stunning in relation to meat quality—A review. *Meat Sci.* 2:19.
- van der Wal, P. G. 1978b. Meat quality aspects on stunning methods. Hearing on Pre-Slaughter Stunning. Swedish Meat Res. Centre, Kavlinge. p 39.