The Effect of Ante-Mortem Epinephrine Injection on Plasma Glucose, Post-Mortem Glycolysis and Meat Quality Factors of West Africa Dwarf Ewes.

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SUMMARY

EIGHT West African dwarf ewes were allotted into two equal groups in an attempt to study the effect of epinephrine on body glucose, post mortem glycolysis and some aspects of meat quality factors. One group was injected subcutaneously a one-shot dosage of 0.1% adrenaline solution at a level of 1.8 mg/10 kg live body weight six hours prior to slaughtering. Blood glucose levels were estimated during the first hour post injection. The other group of ewes which was injected with an equal volume of water served as control. Following death, the pH of the longissimum dorsi was followed as an index of glycolysis. Subsequently, brine diffusion distance, salt uptake, drip loss, cooking loss, total moisture and the organoleptic attributes of tenderness, juiciness, flavour and overall acceptability were estimated in selected muscles.

An overall elevation of plasma glucose by epinephrine was observed during the one hour period of blood collection. A lower than normal initial pH was observed in both groups since both struggled prior to death. The ultimate 24 hour pH was higher in the epinephrine treated mutton (6.43) than in the control group (5.63). Mean drip loss and cooking loss were 1.86% and 30.88% in the epinephrine treated samples as against 1.63% and 33.38% respectively in the control samples.

Higher estimates of diffusion lengths were obtained in the treated samples ($P < 0.05$) although between muscle variations were observed. Slight differences were observed as a result of treatment effect on tenderness, juiciness, flavour and overall acceptability. Between muscle variation in these parameters were highly significant.

INTRODUCTION

Prevalent methods for slaughtering animals in Nigeria necessarily involve a lot of energy utilization during the death struggle. Previous studies by Aberle and Merkel (1968) suggest that the stress of slaughtering produces enough endogenous epinephrine to cause a maximum rate of glycolysis and that the rate of post mortem pH fall and ultimate pH values were not altered by injection of exogenous epinephrine prior to slaughter. Other results obtained by Pearson et al. (1973) have also shown that injection of epinephrine only 5 minutes prior to slaugther did not significantly alter glycolysis or other muscle properties although such muscles were slightly toughened.

In this paper, the effects of injecting epinephrine subcutaneously six hours premortem into West African dwarf ewes have been investigated. These effects have been quantitated through the estimation of blood plasma glucose levels within one hour post injection and post-mortem, through the measurement of changes in muscle pH as an indication of muscle glycolysis. Other quality-indicating characteristics of the raw and cooked meat were also estimated.

MATERIALS AND METHODS

Eight West African dwarf ewes of unknown ancestry, previous feeding regime or management were obtained from the regular commercial outlet at Sango, Ibadan in Western Nigeria. It is believed that these animals were raised somewhere in Northern Nigeria and had just been delivered for sale at the commercial outlet. The ewes ranged from 18·15 kg to 28·48 kg liveweight with an average of 23·2 kg. The average age was estimated to be roughly 36 months based on the scheme of Starke and Pretorious (1955).

The ewes were allotted to two groups each containing four animals. Prior to slaughter, feed was withheld overnight from each group of ewes although they had access to water. Exactly six hours before they were slaughtered, one group of ewes was injected subcutaneously in the right flank with enough 0·1% adrenaline hydrochloride solution to give a final dosage of 1·8 mg/10 kg liveweight. Equal relative volumes of water were injected into the other group. 10 mls of blood samples were withdrawn immediately from the jugular vein of each ewe and again at 30 minutes and 1 hour after the initial sampling.

Blood samples were transferred in centrifuge tubes containing some grains of ethylenediaminetetra-acetic acid (EDTA) and immediately mixed to prevent coagulation. The plasma was separated by centrifugation at 3,000 rpm for 30 minutes, removed by suction into capped vials and frozen until analysed for glucose. The glucose content of the thawed plasma was estimated by the glucose oxidase method using O. dianisidine (Washko and Rice, 1961).

The ewes were exsanguinated without being previously rendered insensible and drained as much as possible. Dressing of each carcass was completed within 20 minutes of death. The initial pH of the longissimus (LD) muscle was taken by inserting the electrode of a pH meter into two slits made in the fiber direction on the muscle at the location between the 12th and 13th ribs and opposite the last lumbar vertebra. The observation was again repeated after 30 minutes, 3, 6, 12, 18 and 24 hours.

Immediately after taking the initial pH, the carcasses were weighed and transferred into a cold room at 0°C. After 24 hours, the two longissimus dorsi, biceps femoris, semimembranosus and semitendinosus muscles were carefully dissected from all carcasses, individually packed in polythene bags and frozen at-29°C. One of each pair of muscles from each carcass was subsequently used for brine diffusion measurements while the other was used for estimation of palatability traits.

In estimating brine diffusion characteristics, a 7·5 cm length of muscle was taken from the thickest portion of each frozen muscle such that the fibers run approximately from one end to the other. A 2·0 cm cylindrical meat core was taken in the fiber direction using a well bevelled stainless steel meat core borer. Each meat core was carefully inserted into a clean 2 cm diameter cylindrical glass tube with a clearance of approximately 1 cm from one end of the glass tube. This space was filled with a spongy foam material which also extended slightly beyond the glass rim. Each glass tube was then clamped upright in a 250 ml beaker containing 50 ml of a brine solution prepared by dissolving 175·0 gm of Nacl, 89·6 gm of commercial sucrose, 2·4 gm of KNO_3 and 0·56 gm of L-Ascorbic acid in 1,100 ml of distilled water. Clearance from the base of the beaker was provided by the spongy foam while the other opened end of the glass tube was plugged with cotton wool.

The curing solution was allowed to diffuse into the meat for 24 hours at room temperature. All the glass tubes containing the meat cores were then packed into a home kitchen pressure cooker and steamed for 5 minutes to fix the cured colour. Subsequently, the meat cores were removed, cooled in air, cut lengthwise symmetrically into two and the length of fixed visual colour estimated as an index of brine diffusion distance.

Two sections were removed starting from the cured end of each core. The lower section contained all the cure diffusate while the next section appeared devoid of cured meat colour. Each section was manually minced. The total amount of salt in aliquots from each section was determined by the acid digestion method based on A.O.A.C. (1965).

The remaining member of each pair of muscles was rapidly sliced into chops 2·5 cm thick while still frozen. The two largest chops from each muscles were rapidly weighed, then thawed completely at room temperature, mopped dry with filter paper and again weighed. The difference in weight was taken as the drip loss. Subsequently, the two chops were broiled in a kitchen gas oven previously preheated to 350°F. Each chop was broiled on each side for 12 minutes at the end of which time it was judged to be of medium doneness. The chops were cooled to room temperature, dried as before, weighed and the difference was taken as the cooking loss.

The cooked chops were sliced into cubes roughly 2·5 cm thick. Cubes from each muscle were subjectively evaluated for tenderness, juiciness, flavour and overall acceptability by a six member taste panel using a nine-point hedonic scale rating.

RESULTS

The changes in the plasma glucose levels in the experimental ewes are shown in figure 1. The initial plasma glucose levels varied from 19 to 33 mg/100 mls of blood in the eight ewes studied. 30 minutes post injection, there was a significant increase ($P < 0{\cdot}01$) in the plasma

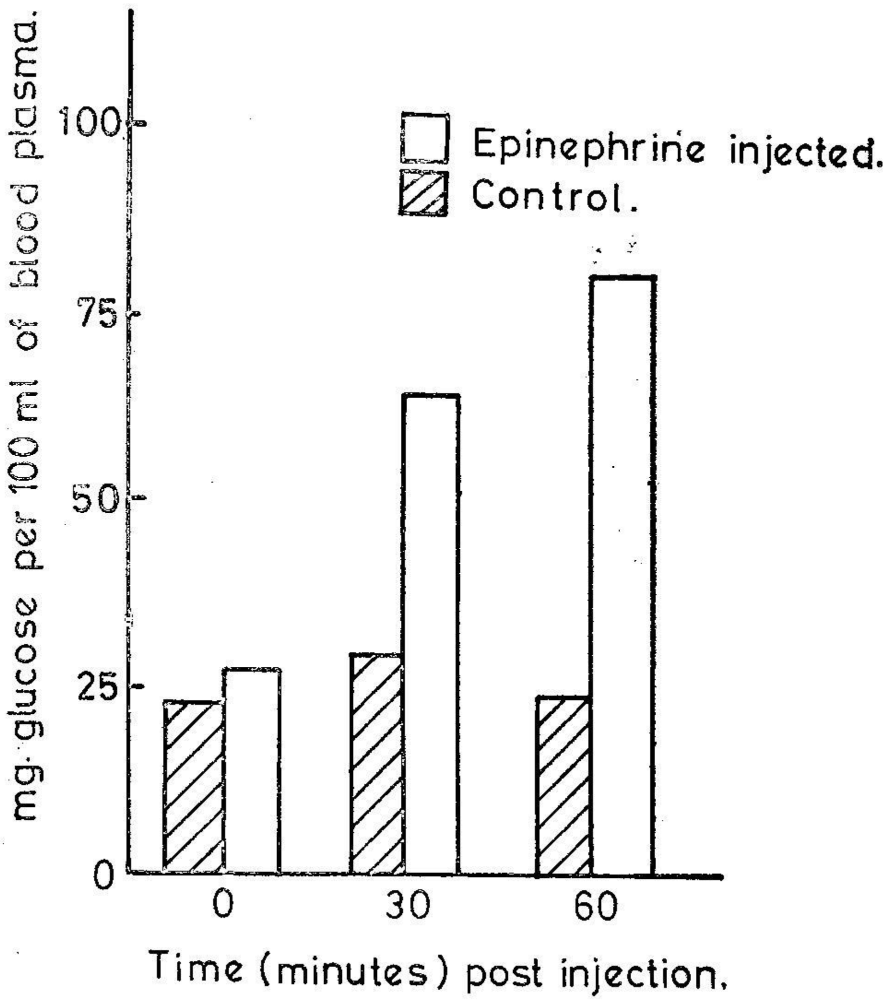

Fig. 1. The effect of subcutaneous epinephrine injection on blood plasma glucose levels.

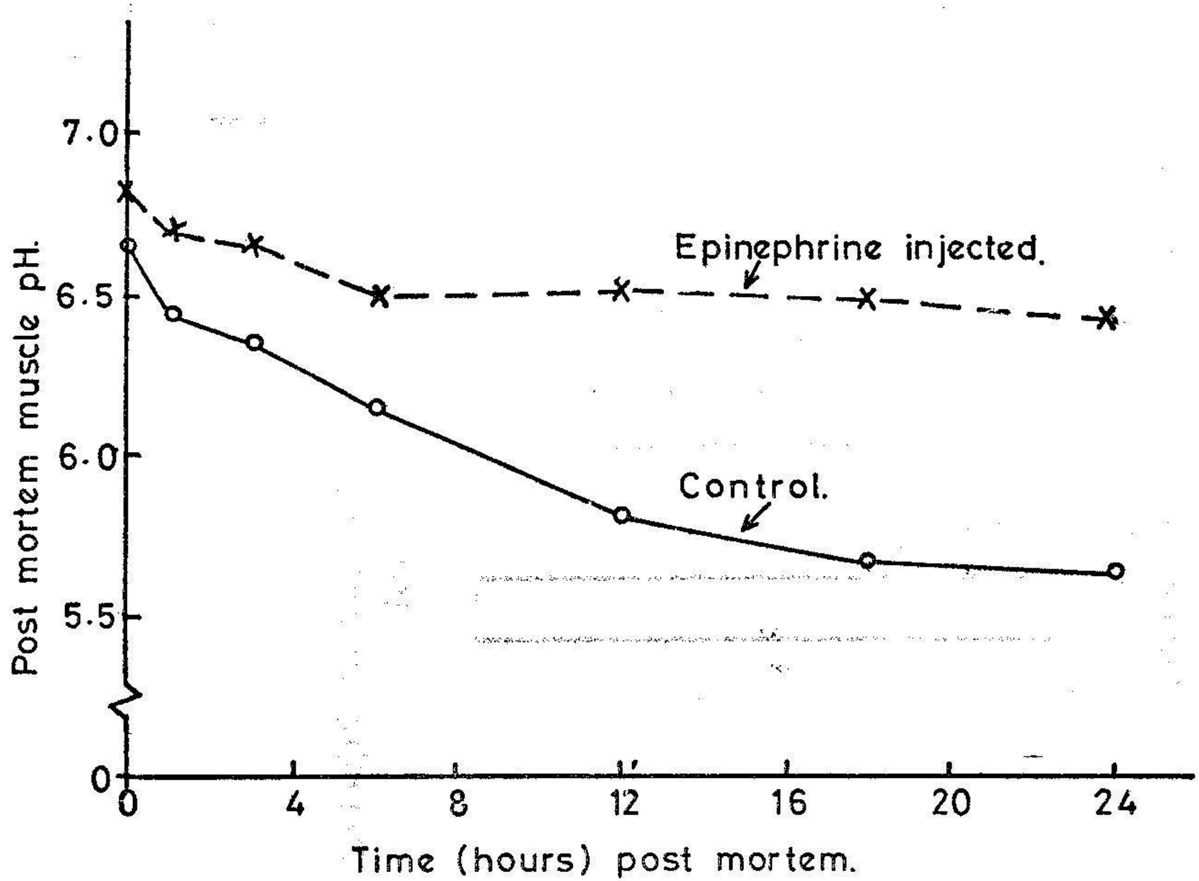

Fig. 2. The effect of pre-mortem administration of epinephrine on post-mortem muscle pH.

glucose level from an average of 27·25 mg percent to an average of 64 mg percent in the epinephrine-injected ewes. The comparative values for the control ewes were 22·75 and 29·75 mg percent respectively. At 60 minutes post injection when blood collection was terminated, the glucose level rose further to a mean of 81 mg percent in the epinephrine-injected ewes while those for the control ewes fell to 24·50 mg percent.

The means of pH values taken on the longissimus dorsi at the locations between the 12th and 13th rib and opposite the last lumbar vertebra in both groups of ewes at various time intervals post mortem are shown in figure 2. The initial pH of 6·66 obtained in the control group is considerably lower than in the treated group which had an initial pH of 6·87. The pH values did not change appreciably (ΔpH of 0·44) during the 24 hour post mortem period in the epinephrine-treated carcass while in the control group, the corresponding change (ΔpH of 1·02) was significant (P < 0·01). The major part of the pH drop appeared to have taken place within the first 12 hours post mortem.

Mean values presented in Table 1 indicate that pre-slaughter injection of epinephrine significantly enhanced the extent of cure diffusion (P < 0·05) as measured by the cure diffusion distance. Further, significant variations (P < 0·01) were noted among the different values for the four muscles. In both experimental groups the semimembranosus exhibited the highest diffusion distance followed in decreasing order of magnitude by the biceps femoris, semitendinosus and longissimus dorsi.

No significant treatment effect or between muscle differences were observed in the percent salt content of the lower cured meat section. However, in the upper uncured meat section, the percent salt content was significantly higher (p < 0·05) in all the muscles from the epinephrine injected ewes. Between muscle differences were also significant (P < 0·01).

Values for drip loss, cooking loss and moisture content are shown in table 2. There was a significant treatment effect with respect to drip loss (P < 0·01). Variation in the muscle characteristics was also evident especially in the semimembranosus which lost more fluid as drip in both the treated and control samples.

The average cooking loss of 30·88% obtained in the treated muscles was significantly (P < 0·05) less than the corresponding value of 33·38% obtained in the control samples. This differential was reflected in the values for all the muscles except the biceps femoris in which 37·09% cooking loss was obtained as against 35·90 % in the control. No statistically discernible difference in the moisture content of the raw muscles was noted.

The treatment effect was significantly (P < 0·05) reflected in the taste pannel tenderness scores (table 3) with the must

TABLE 1

The effect of pre-mortem epinephrine injection on salt content and cure diffusion distance in selected ewe muscles

Muscle type	*Epinephrine injected*				*Control*			
	Longissimus dorsi	Biceps femoris	Semi-membranosus	Semi-tendinosus	Longissimus dorsi	Biceps femoris	Semi-membranosus	Semi-tendinosus
mg % NaCl content (cured meat section	35·80	36·23	35·75	36·27	35·61	35·84	35·72	36·19
mg % NaCl content (uncured meat section)	27·56	28·55	28·16	29·64	24·04	26·13	26·13	26·43
(Cure diffusion distance (cm)	1·55	1·68	2·18	1·60	1·23	1·35	1·81	1·43

TABLE 2

The effect of pre-mortem epinephrine injection on drip loss, cooking loss and moisture content of selected ewes muscle.

	Epinephrine Injected				*Control*			
Muscle type	Longissimus dorsi	Biceps femoris	Semi-membranosus	Semi-tendinosus	Longissimus dorsi	Biceps femoris	Semi-membranosus	Semi-tendinosus
% Drip loss	1·74	1·68	2·09	1·91	1·60	1·59	1·82	1·51
% Cooking loss	26·41	37·09	30·33	29·72	30·57	35·90	34·32	32·78
% Moisture content (Raw muscle)	75·83	78·97	77·93	76·67	74·43	76·80	75·91	74·79

TABLE 3

The effect of pre-mortem epinephrine injection on taste panel scores for various organoleptic attributes of selected ewe muscles.

	Epinephrine injected				*Control*			
Muscle type	Longissimus dorsi	Biceps femoris	Semi-membranosus	Semi-tendinosus	Longissimus dorsi	Biceps femoris	Semi-membranosus	Semi-tendinosus
Tenderness	7·15	4·85	6·25	6·55	5·15	3·70	4·90	6·05
Juiciness	6·90	5·55	6·15	6·15	6·50	5·75	5·90	6·25
Flavour	5·85	5·05	5·95	6·02	6·60	5·25	5·80	6·30
Overall acceptability	5·80	5·05	5·60	6·25	6·80	5·25	5·80	6·60

cles from the epinephrine-injected ewes having an overall mean rating of 6·20 against 4·95 in the control. All muscles were rated higher in the former treatment group. When considered between muscles, the tenderness differences were significant ($P < 0·05$) with the longissimus dorsi receiving the highest scores in both treated and control groups. Significant differences in flavour and juiciness were not detected as a result of the treatment effect or between muscles. On the overall acceptability, the epinephrine-injected ewes were less preferred than the respective controls, although this lacked significance.

DISCUSSION

The initial glucose values observed in the present study for the eight ewes agree with previous values of 18–49 mg percent determined in sheep of mixed British and Australian breeds on low plane of nutrition (Reid, 1950) and of 26·6 mg percent determined in the blood plasma of starved western or dorset ewes (Boyd et al., 1973). The former worker recorded a range of 18–57 mg percent in all plasma glucose determinations. The initial low level of plasma sugar observed in this investigation may be expected considering the fact that the ewes were obtained during the middle of the dry season when natural feed was scarce and this may have been complicated by a previous exposure to the draught condition.

The drastic rise in plasma glucose following epinephrine injection may be attributed to the glycogenolytic effect of the hormone in the liver. This action is known to be mediated through the stimulation of adenylcyclase and subsequent activation of phosphorylase necessary for the conversion of liver and muscle glycogen to glucose. That blood glucose remained high in the treated group after one hour post injection of epinephrine would seem to indicate that epinephrine has a transient inhibitory effect on glucose induced release of insulin or on the effectiveness of insulin in regulating blood glucose levels. This may be a peculiar trait in ruminants in which blood glucose levels fall more slowly even in response to exogenous insulin (Reid, 1951). Glucose arising from epinephrine-induced glycogenolysis in the skeletal muscles is in the short run necessarily metabolised. A significant decrease in the activity of glycogen synthetase in skeletal muscle is enhanced by epinephrine (Belocopitow, 1961) and might have inhibited the conversion of such glucose back to glycogen while the action of the epinephrine remained effective. This then may manifest itself in a depletion of the muscle glycogen reserve.

Preslaughter glycogen depletion with the present dosage of epinephrine was probably effective in preventing appreciable pH drop in the treated group as compared with the control. Previous work by Bendall and Lawrie (1962) has shown that epinephrine accelerates post mortem glycolysis although when injected shortly before slaughter, neither the rate of pH drop nor the ultimate pH are affected (Pearson et al. 1973). Repeated injection of epinephrine spaced over a prolonged period of 12 to 24 hours have been found to raise the ultimate pH of meat and thereby produce dark cutting beef. The present finding shows that repeated injection of epinephrine over a long period is not necessary to exhaust glycogen reserve but rather, this could be achieved in the case of sheep by a one-short dosage of 1·8 mg of epinephrine per 10 kg body weight injected six hours prior to death.

The struggling necessarily involved in the slaughtering procedure used in this experiment and which is the normal method generally used in Nigeria in the absence of any humane slaughtering facilities may account for the initial pH being well below 7·0 which is normally associated with muscle freshly after death (Marsh, 1954). Such struggling is known to elicit the production of endogenous epinephrine which subsequently accelerates glycolysis and, in the short run, enhances the accumulation of lactic acid.

Greater uptake of curing brine as reflected by the higher cure diffusion distances in the muscles from the epinephrine-injected ewes was enhanced by the higher ultimate pH in keeping with previous results by Bouton et al. (1973) with minced mutton in which it was shown that the water holding capacity of meat was superior at high ultimate pH than at low ultimate pH. In a previous work on porcine muscles by Arganosa and Hendrickson (1969) the cure diffusion distances in these muscles were in the same order as observed in this investigation using ovine muscles. The between muscle differences may be due partly to differences in the degree of closeness of the micro-structure of each muscle which affects the capillary movement of the brine in the spaces between its fibres and partly to the inherent myoglobin and total pigment in the fresh tissue as suggested by Hornsey (1964).

The lack of difference in the salt content of the lower cured meat section of the meat cores would be expected if all the muscles were completely saturated with the curing brine. The upper section in all the epinephrine injected muscles contained more salt than the control due to the ionic disturbance in the former.

The higher ultimate pH value resulting from the epinephrine injection enhanced water retention during cooking. Previous work by Hamm and Deatherage (1960) showed an increase in water-holding capacity with increase in pH of beef homogenates cooked at 60°C. Since there is an inverse relationship between cooking loss and water holding capacity, an increase in water-holding capacity would result in a decrease in cooking loss such as was obtained with the epinephrine - injected muscles. The present result is further supported by the finding of Khan and Nakamura (1972a) who observed a pronounced decrease in cooking loss with increase in pH of meat from epinephrine-treated chickens.

The improvement in tenderness rating was expected from previous work by Khan and Nakamura (1972b). Consumer studies have indicated that tenderness is perhaps the most determining attribute of meat. It is therefore not clear whether the panels lack of acceptability for the more tender meat from epinephrine-injected ewes was due to the apparent preference of the average Nigerians for fairly tough chewable meat. More research in this area is needed.

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