EFFECT OF TRANSPORTATION ON THE PERFORMANCE AND CARCASS TRAITS OF HALOTHANE SENSITIVE PIGS

By
MANJU SASIDHARAN

THESIS
submitted in partial fulfilment of the
requirement for the degree of

MASTER OF VETERINARY SCIENCE
Faculty of Veterinary and Animal Sciences
Kerala Agricultrual University

Department of Livestock Production Management
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy, Thrissur

1997

To My Loving Parents

DECLARATION

I hereby declare that the thesis entitled **"EFFECT OF TRANSPORTATION ON THE PERFORMANCE AND CARCASS TRAITS OF HALOTHANE SENSITIVE PIGS"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Mannuthy
4.12.97

Manju Sasidharan

CERTIFICATE

Certified that this thesis, entitled **"EFFECT OF TRANSPORTATION ON THE PERFORMANCE AND CARCASS TRAITS OF HALOTHANE SENSITIVE PIGS"** is a record of research work done independently by Ms. Manju Sasidharan, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr. P.C. Saseendran
(Chairman, Advisory Committee)
Associate Professor
Department of Livestock Production Management
College of Veterinary and Animal Sciences, Mannuthy

Mannuthy

CERTIFICATE

We, the undersigned members of the Advisory Committee of Ms. Manju Sasidharan, a candidate for the degree of Master of Veterinary Science, agree that the thesis entitled **"EFFECT OF TRANSPORTATION ON THE PERFORMANCE AND CARCASS TRAITS OF HALOTHANE SENSITIVE PIGS"** may be submitted by Ms. Manju Sasidharan, in partial fulfilment of the requirement for the degree.

Dr. P.C. Saseendran
(Chairman, Advisory Committee)
Associate Professor
Department of Livestock Production Management

Dr. T.G. Rajagopalan
Professor and Head (Retd.)
Department of Livestock
Production Management
(Member)

Dr. C.K. Thomas
Professor and Head
Department of Livestock
Production Management
(Member)

Dr. N. Kunjikutty
Professor
Department of Animal Nutrition
(Member)

External Examiner

ACKNOWLEDGEMENTS

I am deeply indebted to Dr. P.C. Saseendran, Associate Professor, Department of Livestock Production Management, College of Veterinary and Animal Sciences, Mannuthy for his guidance, incessant encouragement and valuable advice throughout this work.

I wish to express my deep sense of gratitude to Dr. T.G. Rajagopalan, Professor and Head (Retd.), Department of Livestock Production Management, Dr. C.K. Thomas, Professor and Head, Department of Livestock Production Management and Dr. N. Kunjikutty, Professor, Department of Nutrition, members of my Advisory Committee for their valuable suggestions and help.

I am cordially obliged to Dr. T.V. Viswanathan, Associate Professor and Head, Centre for Pig Production and Research, Dr. Joseph Mathew, Assistant Professor and the staff of Centre for Pig Production and Research, Mannuthy for the helps rendered to conduct the research work.

I am grateful to Dr. J. Abraham, Professor and Head, Meat Technology Unit and the staff for their help and co-operation.

I sincerely acknowledge the helping hand extended by Dr. M. Gopalakrishnan Nair, Assistant Professor, Department of Extension, Dr. Mammen J. Abraham, Assistant Professor, Department of Pathology and Dr. T.P. Balagopalan, Department of Surgery for their technical guidance.

I take great pleasure in appreciating the staff members of the

Department of Livestock Production Management, Department of Nutrition and Smt. Santha Bai, Programmer and the staff of Department of Statistics for their co-operation and assistance.

I am grateful to the Dean, College of Veterinary and Animal Sciences, Mannuthy for the facilities provided for this work.

I express my heartfelt thanks to Dr. K.S. Sebastian, Associate Professor, Dr. Francis Xavier, Associate Professor, Dr. Kumaravelu, Assistant Professor, Department of LPM and to my colleagues Reny K. Oommen, Sandhya, Ralston, Ramesh, Mahadevappa Gouri and Subrahmanian for their help, co-operation and motivation for successful completion of this work.

With great fondness I express my gratitude to my friends George Varughese, Manoj Johnson, Shihabudeen, K.P. Mini, Deepa Ananth, Marie Sindhya, Marykutty, Indu. S., Rinita Singh, Indu. V. Raj and all others who helped in my work.

I am thankful to the I.C.A.R. for awarding me the Junior Research Fellowship for the post graduate study.

My heartfelt thanks to M/s Peagles, Mannuthy for its well timed assistance in the preparation of this thesis.

And last, but not the least I thank my brother for his constant inspiration, understanding and blessing for the successful completion of study.

Mannuthy **Manju Sasidharan**

CONTENTS

Sl. No.	Title	Page No.
1.	Introduction	1 - 3
2.	Review of Literature	4 - 21
3.	Materials and methods	22 - 25
4.	Results	26 - 71
5.	Discussion	72 - 83
6.	Summary	84 - 86
7.	References	87 - 103
8.	Abstract	I

List of Tables

Sl.No.	Title	Page No.
1.	Fortnightly body weight of pigs	29
2.	Fortnightly rate of gain in weight	31
3.	Fortnightly body girth	33
4.	Feed conversion efficiency	34
5.	Blood pH	37
6.	Erythrocyte sedimentation rate (ESR)	38
7.	Packed cell volume (PCV)	40
8.	Lactate dehydrogenase	41
9.	Creatine phosphokinase	44
10.	Slaughter weight of pigs	45
11.	Shrinkage during transport	48
12.	Carcass length	49

13.	Dressed weight after beheading	52
14.	Dressing percentage	53
15.	Meat pH	54
16.	Loin eye area	57
17.	Backfat thickness	59
18.	Weight of heart	61
19.	Weight of liver	62
20.	Weight of kidney	64
21.	Weight of spleen	65
22.	Weight of stomach and intestines	66
23.	Weight of meat	68
24.	Meat-bone ratio	69
25.	Chemical composition of liver and kidney	70

LIST OF FIGURES

Fig. No.	Title	Page No.
1.	Growth curve of pigs	30
2.	Rate of weight gain in pigs	35
3.	Feed conversion efficiency of pigs	35
4.	Lactate dehydrogenase levels of transported and non-transported pigs	43
5.	Creatine phosphokinase levels of transported and non-transported pigs	43
6.	Live weight of pigs at slaughter	47
7.	Shrinkage during transport	47
8.	Carcass length of transported and non-transported pigs	51
9.	Dressing percentage of transported and non-transported pigs	51
10.	Meat pH of transported and non-transported pigs	55
11.	Loin eye area	58
12.	Backfat thickness	58

INTRODUCTION

INTRODUCTION

Pig an extremely versatile animal, is able to adapt to a wide variety of circumstances imposed by man and yet retaining its own peculiar individuality. It thrives from artic to tropical temperatures on highly concentrated and bulky feeds and produce high percentage of meat and fat. Being the efficient feed converters and supreme meat producing livestock, they have the best potential to bridge the deficit in meat in India. Welfare problems arise for pigs if they are unable to control events in their environment. (Fraser and Brom, 1990). Inability to prevent attack by another pig, to regulate body temperature or to groom adequately can all lead to poor welfare. Other problems include those due to physical abuse, neglect, handling, transport, farm operations and disease.

Some pigs suffer from an extreme susceptibility to stress, controlled by a single recessive gene, the halothane gene (Hal^n) and are called halothane sensitive pigs (Rundgren et al. 1990a). Halothane anaesthesia induces malignant hyperthermia in recessive homozygotes (nn), but not in heterozygotes (Nn) and dominant homozygotes (NN) (Mitchell and Heffron, 1982). Ever since the halothane gene was first identified, numerous studies have been conducted to compare growth, carcass and meat quality characteristics of halothane genotypes. To date, vast majority of studies, have used the halothane challenge test as a basis for identifying homozygous reactor and non-reactor animals. (Aalhus et al. 1991, Klont et al. 1994). The adverse effect of halothane gene are increased by the stresses of handling, transport and high ambient temperature (Mitchell and Heffron; 1982). This is revealed by industry reports of higher transit death rates in summer (McPhee et al. 1994.)

Commercially, the halothane gene is of interest because it results in increased carcass lean contents (Aalhus et al., 1991; Pommier et al., 1992). However, halothane reactors (nn) in comparison with negative animals (NN), are more stress susceptible and produce poor meat quality, particularly in terms of a higher incidence of pale, soft and excudative (PSE) meat. (Simpson and Webb, 1989; Sather et al., 1991 b, c; Jones et al., 1994). Though genetic selection programmes have emphasised lean meat varieties, such breeds often exhibit increased sensitivity to stress and when slaughtered had rapid postmortem glycolysis in their muscles resulting in PSE meat (Lister, 1970). Because of the lowered water holding capacity which increases the drip loss, it was guessed that some 1500 tonnes of water equivalent to 21,000 pigs was lost from UK pig meat each year due to the Hal gene (Webb, 1995). In order to reduce such a loss pig breeders wanted to select stress resistant genotypes and to avoid sensitive group.

In pig farms, transportation is mainly at two stages, viz., at weaning stage and marketing stage of fattening pigs. During transport or mixing of weaners, vigorous fighting resulted in weight loss. However the knowledge of the effect of this stress on young reactors seems to be limited.

Pig breeding and pork industry is likely to develop at a rapid rate in Kerala involving well acclimatized exotic breeds like Large White Yorkshire. This is indicated from the records of the Pig Breeding Farm, Kerala Agricultural University (KAU), Mannuthy. The sale of piglings to farmers from this farm has been doubled from 1000, piglings per year in 1992 to 2000 piglings in 1996. The hike in the demand of pork was reflected by the increase in number of pigs slaughtered in KAU Meat Technology Unit. (About 600 pigs slaughtered in 1977 Vs 450 pigs in 1996).

Reports on the transportation loss of pigs reared by farmers seem to be limited. Since a large number of piglings are transported from breeding farms to grower and finisher farms, there is a need to study the effects of transportation on the performance of pigs. Similarly transportation to abattoir leads to stress, resulting in inferior meat quality.

This study investigates how halothane positive (Hal+) and halothane negative (Hal-) groups of pigs react physiologically when they are transported, their behavioural and weight changes during transport, and also the effect of transportation on the performance and carcass traits of these pigs. The result of the study helps to quantify the wastage or loss in transportation and its effects on the profit of the farmers.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

In commercial pig production weaners are often transported and/or mixed with unfamiliar pigs resulting in weight losses and vigorous fighting (Dantzer, 1970; Meese and Ewbank, 1973). The knowledge of the effects of transportation on young pigs seems to be limited. Pre-slaughter stress such as fighting, cold weather, fasting and transportation depletes muscle glycogen of finisher pigs resulting in meat which has a higher pH due to lack of lactic acid production (Grandin, 1980). The problem most commonly associated with transporting of animals result from uncontrolled malignant hyperthemia reactions, which can be triggered by milder forms of handling, sexual intercourse, excessive ambient temperature and a number of chemical agents. The "acute stress syndrome" accounts for a substantial number of cases of sudden deaths among pigs. The mortality rate of pigs during transportation is related to the temperature and other environmental factors.

The immediate cause of death in these cases is not known, although Allen et al.(1970) suggested that sudden deaths which they observed may have been caused primarily by functional failure of skeletal muscles resulting from metabolic disturbances. Some pigs are genetically more stress susceptible than others (Marple et al., 1972) perhaps because of differences in endocrine functions. Halothane sensitivity can be used as a field test for stress susceptibility in the pig (Webb and Jordan, 1978).

2.1 Halothane sensitivity in pigs

The genetic basis of malignant hyperthermia can be triggered in stress susceptible pigs by environmental stress or by administration of inhalation anaesthetic, halothane. An evaluation of the halothane test for possible use in genetic improvement programmes was started in 1974 at the Animal Breeding Research Organisation (ABRO) Edinburg.

Halothane (Fluothane), a flourinated hydrocarbon ($CF_3CHClBr$) was found to be a non-inflammable and nonexplosive heavy, liquid with a specific gravity of 1.86 and boiling point of 50.2°C. It is used in closed circuit methods of anaesthetisation with vapour concentration of two-four per cent in the inspired air which produced smooth and rapid anaesthesia in all domestic animals.(Hall,1971).

2.1.1 Procedure

The pigs aged three to eleven weeks and weighing upto 26 kg were gently restrained and allowed to breathe halothane in oxygen via a face mask for upto three minutes. The oxygen flow rate of two to three litres/min and the halothane concentration of four to eight per cent for the first minute and one to three per cent thereafter were regulated so that the eye reflex was lost within one minute (Webb and Jordan, 1978).

Reactions were assessed visually by the degree of rigidity of the hindlegs (Sybesma and Eikelenboom, 1969) and were scored 'positive' 'doubtful' or `negative' where a positive reaction was defined as extreme rigidity. Pigs reacting positively to halothane anaesthesia had considerably elevated body temperature, increased frequency of respiration and pulse and tonic muscular contraction of limb extensors within three minutes of halothane administration. Pigs not reacting to halothane did not show these symptoms throughout the four minutes period of halothane application (Bulla et al., 1991). A typical positive reaction involve muscle stiffness irregular respiration, increased temperature, respiratory acidosis and death, with resulting low intramuscular pH leading to inferior meat quality (Davies, 1994).

2.2 Behaviour

Behavioural studies of pigs during handling and transport confirm that loading has the biggest effect on welfare. Animals resist attempts to move them, vocalise and adopt defensive postures frequently during loading. Behavioural indicators of poor welfare during the journey are usually associated with inappropriate temperature, high stocking density or poor driving (Fraser and Broom (1990); Van Putten and Elshof, 1978). Fighting is rare during movement but can cause serious problems when the vehicle is stationary (Pearson and Kilgour, 1980). Sather et al. (1995) reported that the greatest amount of aggressive pen activity occurred, within the first hour of mixing, but the activity persisted for atleast 12 h after mixing. Disturbing the pigs by moving to the abattoir also caused high levels of activity. According to them mixed pigs accounted for 75 per cent of aggressive activity.

Shaefer et al. (1989) constructed ethograms of pigs from three genotypes segregating at the halothane locus. Halothane positive pigs drank and ate less frequently and spent longer investigating their pen than negative pigs or the progeny. The former group also slept less frequently in groups and were less aggressive than the heterozygotes and halothane negative groups. Halothane positive pigs and their progeny displayed a greater level of neutral or non-aggressive acts including nose to nose and nose-body contact than negative pigs. However when fasted for 24-48 h all genotypes behaved similarly with low levels of most of their behavioural traits.

Rundgren et al. (1990) reported that the frequency of attacks and retreats did not differ between the Halothane genotypes, but a tendency towards an interaction with sex was found. Gilts attacked more than castrates, and among the latter the number of attacks was higher for NN (homozygous halothane resistant) than for the nn (halothane sensitive) pigs, where as among the gilts this order was reversed. During transport, 90 per cent of the time pigs were lying side by side (Geers et al., 1994). Feeding during transport will increase heat production and may have a cumulative effect on the rise of body temperature due to transport itself.

Following transportation, and release into a seminatural environment, the activity was higher on the first four days after release and the social tension higher (Wood et al., 1990).

Ekkel et al. (1996) compared the behaviour of pigs housed in specific-stress - free (SSF) system in which they stay in their pen from birth to slaughter with pigs which are transported and mixed once at approximately 25 kg. The agonistic behaviour was higher for transported pigs than for those housed in SSF system.

2.3 Growth performance

Halothane gene has economically important beneficial and harmful effects on growth performance. For males on adlib feeding, daily gain was significantly lower in hyper-susceptible pigs than in others (797 Vs 842 g) and duration of fattening was significantly longer (111.1 Vs 103.6 days) the difference in females were non-significant (Eldik and Van, 1975). Gilts from Dutch Yorkshire and Dutch Landrace pigs showed no difference in growth traits between halothane susceptible and resistant pigs (Eikelenboom et al., 1978).

Oster (1980) reported that with negative, doubtful and positive reactors daily gain averaged 845, 838 and 824 g respectively. Poltarsky and Bulla (1984) also observed higher daily gains in negative pigs. Similar results were obtained by Wilde and Wilde (1984), Jensen and Barton Gade (1985), Janciene (1989), Timofeev et al. (1990), Babeev et al. (1991) and Babeev and Kazachok (1992) reported that the average daily gain was higher for halothane resistant pigs. Uremovic et al. (1993) studied the growth rate of halothane susceptible pig and found that the growth rate of halothane resistant pigs was non-significantly superior to that of susceptible pigs.

McPhee et al. (1994) observed that the halothane allele reduced appetite and growth rate. Matthes et al. (1995) found a decrease in daily gain for positive pigs.

In contrast to the above results, Luescher et al. (1979) and Kadima et al. (1985) reported that halothane carriers grew faster than negative pigs. While studying the daily gain of finishing pigs, Whitmann et al. (1993) observed a higher daily gain for heterozygotes followed by sensitive pigs. Halothane resistant pigs had the least gain.

Several studies have shown little difference in growth rate between the two genotype (Simpson and Webb, 1989; Sather et al., 1991; Pommier et al.; 1992, Fewson et al., 1993 and Gueblez et al.,1995). Piglet weight at birth and at three, six and nine weeks did not differ between the Hal genotypes (Rundgren et al., 1990a).

Transportation distance was not correlated with mean daily gain (Sather et al., 1983). Rundgren (1988) reported that pigs both Halothane positive and negative that had been transported at 25 kg live weight for 5 h had lower carcass lean contents at 100 kg than those not been transported. But, there was no interaction between the halothane genotype and transport at 25 kg on pigs growth performance. In this experiment the immediate effects of both transport and mixing were limited. Mixing resulted in decreased growth rate for barrows but not for gilts during the entire growing period.

Effect of transportation on piglet performance was studied by Jeese et al. (1990). They found that transportation for 563 km did not affect the subsequent health or performance in fasted or nonfasted pigs. Rundgren et al. (1990) also reported that daily gain was not significantly affected by transport. Overall daily gain in the first thirteen days after transport did not differ among the treatment groups nor among halothane genotypes.

2.4 Feed conversion efficiency

A feed conversion efficiency of 3.94 and 3.83 for Large White Yorkshire was reported in a study at Mannuthy by Saseendran and Rajagopalan (1981).

Wilde and DeWilde (1984), Babeev and Kazachok (1992) and McPhee et al. (1994) reported that the halothane negative pigs consumed less feed per kilogram gain. Contrasting results were obtained by several workers where halothane positive animals showed significant improvements over negative in feed conversion efficiency (Webb and Simpson, 1986). Sencic (1989) and Leach et al. (1996) said that halothane carrier (Nn) pigs had better feed conversion efficiency than halothane negative pigs. Feed consumption tended to be lower in halothane positive (nn) pig than the other genotypes, but the growth rate was similar for all genotypes indicating better feed conversion efficiency for nn pigs.

Webb and Jordan (1978), Timofeev and Luk-yanov (1990), Sather et al. (1991) and Fewson et al. (1993) found no difference in feed conversion efficiency between stress tolerant and stress sensitive pigs.

Rundgren (1988) mixed and transported pigs at 25 kg live weight for five hours and found that it decreased the feed conversion efficiency for barrows. But gilts were not affected. Jeese et al (1990) reported that provision of feed and water or water alone during transportation did not affect subsequent health or feed efficiency compared with fasted pigs.

The feed to gain ratio was not significantly affected by the transport (Rundgren et al, 1990b) which is in accordance with the limited effects seen immediately after the transportation (Rundgren et al, 1990a).

2.5 Haematological changes

2.5.1 pH of blood

The negative logarithm of the hydrogen ion concentration is pH. For accurate measurement of pH, blood must be examined under conditions that prevent loss of its gases, particularly carbondioxide (Swensen, 1992). The pH of the blood of a variety of vertebrates, both warm and cold blooded, usually varies around values between about 7.4 and 8.0 (Schmidt-Nielsen, 1990).

Blood pH was positively correlated to blood bicarbonate and base excess and negatively correlated to serum chloride. Bicarbonate is the principal buffer in the blood. It reacts with hydrogen ion in the blood forming carbonic acid which is broken down to carbon-dioxide and water (Boles et al., 1994). The carbondioxide is then excreted by the lungs. The relation between blood pH and bicarbonate is expected so that blood pH can be maintained within a narrow range. Malignant hyperthermia caused acidosis which resulted in a decrease in blood bicarbonate level and an increase in chloride content.

2.5.2 Erythrocyte sedimentation rate (ESR)

ESR is a test performed on blood to help to determine the health of the animal. An anticoagulant is used to keep the cell volume constant. ESR for pig is 0-6 mm in 30 min and 1-14 mm in one hour (Coffin, 1953). ESR is measured, in standard tubes, by the distance in millimetres through which the uppermost layers of erythrocytes pass in a certain length of time.

A rapid ESR in newborn pigs usually develops quickly if the pigs are not provided with adequate iron.

Fahraeus (1929) made a detailed study of suspension stability of erythrocytes. He found that changes in the viscosity of the plasma, the specific gravities of the corpuscles or plasma, or the size of the erythrocytes had practically nothing to do with the sedimentation rate. The only factor of importance is the degree of agglutination of erythrocytes, and it is certain that the plasma proteins markedly influence this factor. According to some workers, it is an increase in the fibrinogen content of the plasma that hastens agglutination and settling, while according to others it is an increase in the globulin.

Changes in the ESR are nonspecific reactions and do not indicate a pathological condition. ESR is not pathognomonic for the diagnosis of a specific disease; it merely helps in the evaluation of the health status of the animal.

During stress, when the hypothalmus, adenohypophysis and adrenal cortex are activated, regardless of the source, the plasma iron decreases (Hamilton et al., 1950; Cartwright et al., 1951). Simultaneously with the lowering of the plasma iron, ESR increases.

2.5.3 Packed cell volume (PCV)

Wintrobe haematocrit tube is centrifuged at 3000 rpm for 30 minutes, then the percentage of packed red cells is read from a scale or calculated. Excitement may increase not only the haemoglobin concentration but also the PCV and erythrocyte numbers. This is due to the release of catacholamines (epinephrine and norepinephrine) causing an increase in blood pressure and the contraction of spleen mobilising erythrocytes in the circulatory system (Swensen, 1970).

PCV increased progressively with longer times after food withdrawal and this was associated with increased concentration of plasma protein indicating that haemoconcentration, rather than spleenic contraction was the cause (Warris and Brown, 1983).

2.5.4 Blood enzymes

The pale soft exudative (PSE) condition is considered to occur due to muscle degeneration (Ludvigsen, 1954) consequently enzymes such as creatine kinase (CK) and lactate dehydrogenase (LDH) occur at high levels in the blood due to tissue damage. This can be used in identifying stress sensitive pigs. Higher plasma levels of CK and LDH had been found in stress sensitive breeds of pigs, such as Pietrain and Poland China, than in Chester White or Large White pigs which have an adequate stress response (Allen and Patterson, 1971; Reddy and Kastenschmidt, 1971). There are conflicting reports on the accuracy of these serum enzyme activities in the prediction of stress sensitivity and the PSE condition (Schmidt et al., 1973).

Allen and Patterson (1971) showed the site of blood sampling to be important and suggested that this may be due to local tissue damage. Moss (1978) reported a significant progressive increase in serum enzyme activities when animals were taken from farm to slaughter house, although the magnitude of the change varied for different enzymes.

Men have higher serum CK activities than women (Meltzer and Holy, 1974) and this may reflect greater stress sensitivity in males or it may relate to physical activity. The cortisol and thyroxine levels of boars and gilts indicate that boars may be more susceptible to stress (Moss and Robb, 1978). The greater increases in the serum CK and LDH in boars than gilts after overnight lairage could be explained by boars being more susceptible to stress. The boars are more easily excited and this excitement results in increased physical activity and fighting. This is supported by behavioural observations which show that boars tend to mount each other in lairage and do not settle down as readily when held in lairage overnight (Moss, 1978).

Plasma pyruvate kinase (PK) activity (NN:Nn:nn ratio equals 1:3:7) seems to be more sensitive indicator of stress susceptibility than the CK activity (NN:Nn:nn ratio equals 1:1.5:2) (Warnants et al., 1973).

Creatine kinase test can also be used as a selection criterion to estimate stress resistance and meat quality of transported pigs (Bickhardt et al., 1977). Pietrains showed higher creatine kinase activity than Yorkshire or Minnesota or their crosses after transportation stress. Caola et al. (1978) measured the serum LDH in 64 pigs transported for 10-40 km and in 26 transported upto 80 km. No clear difference between the two groups were established but LDH values were above normal for both groups.

Nikitchenko et al. (1986) have found a significant difference in blood content of LDH between halothane positive and negative animals. Janezic et al. (1988) and Bulla et al. (1988) noticed a significant increased creatine kinase activity after stress in halothane positive animals. Later Szilagyl et al. (1989) and Schaefer et al. (1990) found an elevated CK and LDH activities as an indication of enhanced susceptibility to stressors. Rundgren et al. (1990) also reported increased CK activity after transport.

2.6 Carcass traits

Studies on the genetic association between carcass traits in pigs suggest that both the halothane allele (Webb et al. 1992) and other gene (Hovenier et al., 1993) which increase carcass lean are likely to be associated with an increase in pale soft exudative (PSE) pork under normal conditions of growth and slaughter.

Sather et al. (1991) reported that carcass quality did not differ between the halothane positive and negative groups. Babeev and Kazachok (1992) observed that stress resistant pigs were superior to susceptible pigs for carcass traits.

If the stress of transportation to the abattoir is too great, and pigs are slaughtered immediately on arrival the quality of meat may be affected (Goossens, 1973).

2.6.1 Shrinkage

Tissue shrinkage begin during the early part of journey, and continued at a relatively uniform rate for 90 h, and then diminished. Dantzer (1970) noted a decrease of initial weight of 3.3 per cent for pigs during a four hour transport, of which one-third was faeces and urine. According to Shutz (1975) weight loss during transportation ranged from 1.2 to 2.3 kg. Rundgren et al. (1990a) reported a loss of weight of about 3 per cent of their weight for both halothane positive and negative groups. In another study, Chen et al. (1995) recorded a weight loss of upto 32 per cent. The castrates lost more weight than the gilts and recovered more slowly. The loss is mainly of water by sweating and respiration and waste materials in urine and faeces. The factors affecting this loss are body condition, state of repletion, season and journey time. Pigs lost 2.2 to 5.4 kg of their live weight during 24 h transport.

Rundgren et al. (1990a) reported that the transported animals started to recover the lost weight within three days after transport. The animals compensated for the loss in weight in one week and the daily gain upto thirteenth day did not differ between the transported and nontransported group.

2.6.2 Carcass length and dressing percentage

Sabec et al. (1987) pooled the carcass length of halothane positive and intermediate animals and found it to be shorter than with halothane negative animals, although the difference was not significant. In pigs positive and negative for stress susceptibility the carcass length was 1011 and 1028 mm (Bergonzini et al., 1988). In homozygous halothane negative, heterozygotes and homozygous halothane positive, Wittman et al. (1993) reported a carcass length of 100.9, 99.2 and 95.5 cm. Leach et al.

(1996) found no genotype difference in carcass length. Among transported pigs dressing percentage was higher for reactors (Rundgren, 1988). Sather et al. (1991a) found that the dressing percentage did not differ between halothane positive and negative pigs. Kortz et al. (1995) reported that for pigs transported less than 25 km or more than 50 km before slaughter the dressing percentage was 74.2 and 77.5. It was higher for heterozygotes than homozygous halothane negative pigs (Leach et al, 1996).

2.6.3 Meat quality

Halothane reactors (nn) in comparison with the negative animals, are more stress susceptible and produce poor quality meat (Simpson and Webb, 1989; Sather et al., 1991b,c; Jones et al., 1994). The meat quality of the heterozygotes is generally considered to be intermediate (Sather et al., 1991) between the homozygotes (NN and nn). The halothane negative individuals had higher meat quality scores and less muscling than halothane positive animals (Zhang et al., 1992). Carrier had lower subjective meat quality scores and a higher drip loss than resistant pigs (Leach et al., 1996).

Rundgren (1988) reported that carcass and meat quality of transported heterozygotes were intermediate to those of homozygotes. Chen et al. (1995) observed that transport conditions did not affect meat quality.

Meat quality and the percentage of normal meat were higher for pigs transported over a shorter distance than pigs transported for longer distance (Kortz et al., 1995a).

2.6.3.1 Meat pH

Seller et al. (1988) have reported that the final pH of meat was not significantly affected by halothane genotype.

Sencic et al (1989) found that for pigs susceptible and non susceptible to halothane anaesthesia, meat pH averaged 6.44 and 6.56 respectively. For halothane resistant homozygotes, heterozygotes and halothane susceptible homozygotes the meat pH one hour after slaughter were 6.05, 5.88 and 5.89 respectively (Holkova et al, 1992). Mlynek (1992) and Fewson et al (1993) observed that halothane positive pigs have a lower meat pH in the loin. Halothane susceptibility strongly influences the rate of pH fall and the concomittant development of pale soft exudative meat, but it is related to ultimate pH (Jenson and Barton-Gade, 1985; Lundstrom et al, 1989; Casteels et al, 1995; DeSmet et al, 1996).

Grandin (1980) reviewed the effects of preslaughter stress such as fasting and transportation which occurs 12 to 48 hours prior to slaughter depletes muscle glycogen, resulting in meat which has a lower pH. Neither transport distance nor length of rest period had a significant effect on meat pH in the Longissimus dorsi and Semimembranosus muscles 45 min after slaughter, but carcasses from pigs rested for 24 hr had a significantly higher meat pH. There was a significant transport x rest period interaction for initial pH (Culau et al, 1993).

The pH of meat did not change consistently as transport distance increased, although values for the longest transport distance were higher than those for the shortest distance (Provaznik and

Valenta, 1994). Transport for more than two hours, high loading density and high humidity during transport had an adverse effect on meat pH, and pigs with a waiting period of more than 60 min before slaughter had a lower meat pH than those slaughtered within one hour (Wenzlawowicz et al., 1996).

2.6.3.2 Pale soft exudative meat

The halothane reactors (nn) in comparison with negative animals (NN) produce higher incidence of pale soft and exudative (PSE) meat (Webb and Simpson, 1986; Simpson and Webb, 1989; Sather et al., 1991; Jones et al., 1994 and Leach et al., 1996).

The percentage of normal (non-PSE) meat was highest for pigs rested for two or 18 hr after transportation upto 20 km(Provaznik and Valenta, 1994). The highest incidence of PSE meat was found in pigs transported over shorter distances (upto 10 and 20 km) and rested for one to four hours before slaughter (Valenta and Provaznik, 1995).

2.6.4 Loin eye area

Stress positive animals were significantly more heavily muscled than resistant animals with large loin eye areas (Mabry, 1977). Bergonzini et al. (1988) compared the carcass traits of positive and negative pigs and found that the cross-sectional area of Longissimus dorsi were 30.8 and 27.9 cm^2. For halothane resistant (NN), heterozygotes (Nn) and halothane sensitive (nn) pigs, Beckova and Holkova (1988) observed an eye-muscle area of 50.0, 47.5 and 53.0 cm^2 the differences being non significant. Leach et al. (1996) observed no genotype difference for loin eye area. The eye muscle area was greater in positive than in negative animals (Kralik et al 1988; Poltarsky, 1989 and Podogaev, 1989; Schwerin and Kallweit, 1991) for NN, Nn and nn genotypes eye muscle area was 43.9, 43.3 and 46.2 cm^2 (Matthes and Schwerin, 1995).

Significant difference in eye-muscle area (38.3, 43.4 and 43 cm^2) were obtained between halothane genotypes, the positive animals with greater muscling (Holkova et al, 1992). Contrasting results were obtained by Babeev et al. (1992). They reported that halothane resistant pigs had a consistent superiority for loin eye area over susceptible pigs.

2.6.5 Backfat thickness

Webb and Jordan (1978) found no significant difference in backfat thickness between halothane genotypes. The backfat thickness of NN, Nn and nn pigs were 23.3, 21.5 and 21 mm, the difference being non significant (Beekova and Holkova, 1988). Halkova et al. (1992) and Leach et al. (1996) while studying the performance of different genotypes in relation to the halothane locus found no significant difference in backfat thickness between the genotypes.

Sabec et al. (1987) detected a significant relationship between backfat thickness and halothane susceptibility, with thicker back fat in halothane negative than in halothane positive animals. The average back fat thickness of halothane positive and negative animals were 29.1 and 32.6 mm (Kralik et al., 1988). Bergonzini et al. (1988) found that in pigs positive and negative for halothane susceptibility backfat thickness were 33.6 and 36.6 mm respectively.

2.6.6 Organ weights

Nystrom and Anderson (1987) reported lower stomach weights for halothane sensitive (nn) pigs. Jones et al. (1988) had found that relative to live weight, nn pigs had a significantly higher proportion of carcass and lower proportion of body organs.

The fresh weights of heart, spleen, stomach and flare fat were significantly lower for halothane positive (nn) pigs than for the homozygous negative (NN) and heterozygous (Nn) pigs (Rundgren et al, 1990b). Heart weights as percentage of body weights was less for nn pigs (Berg and Hausmann, 1991). Weight of liver and kidney were lower for nn pigs than for Nn pigs (Nystrom and Anderson, 1993).

The differences in organ weights between the transported and non transported groups were small and non-significant, except for the adrenals, which were heavier for the non-transported than for pigs in the transported group (Rundgren et al, 1990b).

2.6.7 Crude fat content of liver and kidney

The crude fat content of liver and kidney dry matter did not differ between the genotypes. The transported pigs had lower carcass lean content and a tendency towards higher flare fat compared with the non-transported. The crude fat content of liver dry matter was increased by transport and amperozide treatment (Rundgren et al., 1990b).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1 Experimental animals

A group of pigs in the Kerala Agricultural University Pig Breeding Farm in the age group of six to eight weeks and similar in body weight were subject to the halothane test until sufficient number of halothane positive and negative animals were identified. Twelve halothane positive and twelve halothane negative pigs were selected at random from among the tested pigs.

3.1.1 Halothane test (Webb and Jordan, 1978)

The pigs were allowed to breathe halothane in oxygen in a face mask for upto 3 min. The oxygen flow rate (2 to 3 litres/min) and the concentration of halothane (4 to 8% for the 1st min and 1 to 3% thereafter) were regulated so that the eye-reflex was lost within one minute. Reactions were assessed visually as the degree of rigidity of the hind legs and were scored as 'positive' (nn), 'doubtful' (Nn) or 'negative' (NN) where a positive reaction was defined as extreme rigidity.

3.1.2 Allocation of experimental animals to treatment groups

The pigs were assigned to four treatment groups as given below:

Group I - Hpt - Six halothane positive pigs subjected to transportation

Group II - Hnt - Six halothane negative pigs subjected to transportation

Group III - Hp - Six halothane positive pigs not subjected to transportation

Group IV - Hn - Six halothane negative pigs not subjected to transportation

3.2 Management

The pigs were housed in identical sties with concrete flooring and each having a covered area of 6.1 m^2. All the sties had access to exercise yards with wallowing tank and were cleaned daily.

Pigs were fed with standard concentrate ration having 18 per cent crude protein and 3000 ME upto the age of 5 months, and with 14 per cent crude protein during the rest of the study. Monthly deworming was practiced.

Male animals were kept castrated.

3.3 Transportation

Animals from the groups I and II were subjected to transportation at three months of age in the beginning of the experiment and at the end of experiment at seven months of age. The animals were transported for five hours at an average speed of 30 kmph. Transportation was done in an open truck and a space of 0.5 m^2 was provided per animal. The vehicle halted twice during transport, after two hours and four hours.The behavioural changes of the animals were observed during transport.

3.4 Blood sampling and analysis

Whole blood and serum were analysed immediately after grouping into halothane positive and negative groups, at the end of transportation at 90 days and 210 days of age and during the growing period of four months and six months of age.

Blood was collected from anterior venacava, after restraining the animals in lateral recumbency. This procedure was followed till the animals were four to five months old. Later blood was collected from the internal ear vein and while sticking at the time of slaughter. Blood was transferred into two 10 ml tubes one containing heparin and other tube allowed to clot at room temperature for 30 minutes and stored in a refrigerator for 6 hours before separating the clot and serum by centrifugation.

The heparinised blood samples were then used to determine blood pH using pH meter with a glass electrode. The erythrocyte sedimentation rate was determined according to Wintrobe and Landsberg (1935). Packed cell volume was determined according to Wintrobe (1929).

Non hemolysed serum samples obtained were assayed for creatine kinase (Strehler and McElroy, 1957) and lactate dehydrogenase (Bergmeyer, H. W., 1965; Searey, R.L., 1969).

3.5 Observations

Fortnightly feed intake, average fortnightly gain in body weight and body measures were recorded.

Animals were slaughtered after 210 days of age. Live body weight at slaughter, carcass weight after beheading and individual organ weights were recorded and dressing percentage calculated.

Carcass length was measured as the straight line distance from the symphysis pubis to the anterior edge of the first rib taken on a suspended carcass (Krider and Carroll, 1971).

The loin eye area was calculated by making the outline of the Longissimus dorsi muscle between the tenth and eleventh rib (Krider and Carroll, 1971).

Back fat thickness was measured at several points at the first rib, last rib and last lumbar vertebra and the average is taken (Krider and Carroll, 1971).

pH of meat from the Rectus femoris was estimated using a pH meter 45 minutes after slaughter.

Dry matter of liver and kidney were estimated according to AOAC (1984).

Crude fat content of liver and kidney were estimated according to Folch et al. (1956).

Data were analysed as suggested by Snedecor and Cochran (1967).

RESULTS

4. RESULTS

A study was conducted to find out the effect of transportation on the performance and carcass traits of halothane sensitive pigs.

4.1 Behaviour

During the growing period the halothane negative group exhibited more investigatory behaviour and most of the animals were moving about the pen in the morning hours, whereas the positive animals huddled together. At the time of cleaning the pen, all the groups were active, and exhibited playful behaviour. Cheek-to-cheek fighting in which piglet bites and roots at the others face, neck and shoulder was seen more in halothane negative group. The bouts of chases were usually brief. The number of bruises and bitten tails were more among the negative pigs.

Better feeding temperament was shown by the positive groups. They ate faster and drank water more frequently than negative group. The number of fights occurred during feeding were more for negative pigs.

At the time of transportation at 90 days of age both the halothane positive and negative animals were in standing posture. The animals stood parallel to the direction of transit or perpendicularly, with their sides touching each other. When the vehicle stopped after two hours, the halothane negative animals attacked more frequently and within few minute after the halt vigorous fighting was seen among the pigs. Fighting stopped when the vehicle started running, and all the animals were in standing posture. When the vehicle halted again, after three hours of transit, all the animals except one negative pig lied down. The animals stood up again when the vehicle started. After four hours, the animals were lying down even when the vehicle was moving. Nearly seventy per cent of the transported positive pigs had drooling of saliva by four hours and fifteen minutes of journey, with increased respiration. After reaching back the farm, the animals were offered feed and water. There was no sign of feed rejection and the pigs drank water and ate feed immediately when offered.

During transportation at 210 days of age, fighting was observed as soon as the halothane positive and negative pigs were mixed before loading. Both the genotypes exhibited increased respiratory rate after loading. Panting and drooling of saliva were observed for all animals within half an hour of transport.

After one hour journey the animals started lying down. Even when the vehicle stopped, there was no change in the behaviour. All seemed to be under severe stress and had frothing and drooling of saliva.

This continued till the animals were unloaded at the Meat Technology Unit. In the lairage, the animals preferred to be in the wallowing tank even after one hour. Though the place was a novel environment the pigs didn't show any investigatory behaviour, and were resting.

4.2 Growth

4.2.1 Body weight

The fortnightly body weight of transported and non-transported pigs of halothane positive and negative pigs from weaning to seven months of age are presented (Table 1) (Fig. 1).

The average weaning weights of halothane negative and positive pigs of the non-transported group were 7.75 ± 0.75 kg and 8.5 ± 0.61 kg and that of transported pigs were 8.2 ± 0.56 kg and 8.17 ± 0.48 kg respectively.

By seven months of age the non-transported halothane negative and positive animals attained a body weight of 66 ± 2.12 kg and 58.67 ± 5.0 kg and the transported animals 65.5 ± 2.47 kg and 61.17 ± 3.24 kg respectively.

The body weight of pigs at 210 days of age did not differ significantly between the transported and non-transported groups or between the genotypes.

4.2.2 Rate of gain in weight

The fortnightly rate of gain in weight of non-transported and transported pigs of halothane negative and positive genotypes are presented (Table 2) (Fig. 2).

Among the non-transported animals, the fortnightly growth rate ranged between 1.75 kg to 9.65 kg with an average of 5.39 ± 0.59 kg

Table 1. (a) Fortnightly body weight of pigs (kg)

Age in fortnights	Non-transported		Transported	
	Hal-	Hal+	Hal-	Hal+
Initial	7.75± 0.75	8.50± 0.61	8.20± 0.56	8.17± 0.48
1	9.50	10.58	10.40	10.33
2	13.33	12.92	13.30	12.33
3	15.92	15.58	18.00	15.42
4	22.67	23.00	25.00	23.00
5	29.80	28.33	33.20	28.50
6	39.00	37.67	42.50	38.75
7	44.60	44.33	49.20	44.17
8	54.25	48.33	55.20	49.67
9	58.25	55.50	59.40	56.00
10	66.00± 2.12	58.67± 5.00	65.50± 2.75	61.17± 3.24

(b) Body weight at 210 days of age (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	66.00 ± 2.12	65.50 ± 2.47	65.72 ± 1.57
Hal+	58.67 ± 5.00	61.17 ± 3.24	59.92 ± 2.87
Mean	61.60 ± 3.22	63.14 ± 2.11	62.40 ± 1.85

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	168.789	168.789	2.31 NS
Between transport	1	7.816	7.816	2.31 NS
Interaction	1	11.489	11.489	0.61 NS
Error	17	1242.167	73.069	

NS - Non-significant

Fig.1 GROWTH CURVE OF PIGS

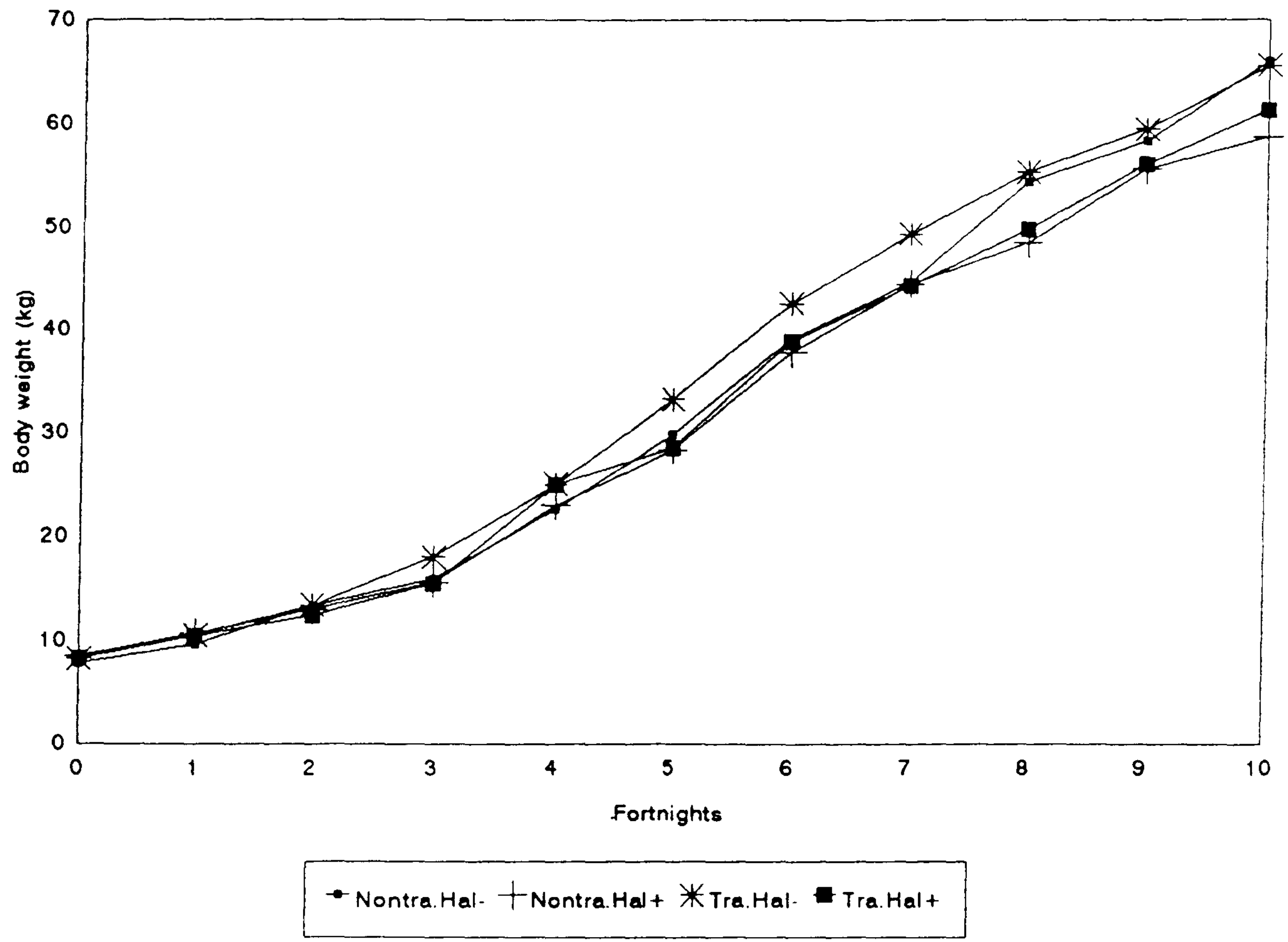


Table 2. (a) Fortnightly rate of gain in weight (kg)

Age in fortnights	Non-transported		Transported	
	Hal-	Hal+	Hal-	Hal+
1	1.75	2.08	2.20	2.16
2	3.83	2.34	2.90	2.00
3	2.59	2.08	4.70	3.09
4	6.75	7.42	7.00	7.48
5	7.13	5.33	8.20	5.50
6	9.20	9.33	9.33	10.25
7	5.60	6.66	6.70	5.42
8	9.65	4.00	6.00	5.50
9	4.00	7.17	4.20	6.33
10	7.75	3.17	6.10	5.17
Average groupwise	5.82± 0.86	4.96± 0.82	5.73± 0.71	5.29± 0.79
Average treatmentwise	5.39± 0.59		5.51± 0.52	

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	5.825	5.73	0.0851	NS
NT+ Vs T+	4.958	5.29	-0.2916	NS

NT- : Nontransported halothane negative group
T- : Transported halothane negative group
NT+ : Nontransported halothane positive group
T+ : Transported halothane positive group

(c) ANOVA

Source	Degrees of freedom	Sum of squares	Mean square	F value
Halothane genotypes	1	4.271	4.271	0.6717 NS
Transport	1	0.140	0.140	0.0221 NS
Halothane x Transport	1	0.456	0.456	0.0717 NS
Error	36	228.897	6.358	

NS - Non-significant

and for the transported animals the fortnightly growth rate ranged between 2.0 kg to 10.25 kg with an average of 5.51 ± 0.52 kg.

For the non-transported halothane negative and positive animals, the average growth rate was 5.825 ± 0.86 kg and 4.958 ± 0.82 kg, and for the transported halothane negative and positive animals the average fortnightly gain was 5.73 ± 0.71 and 5.29 ± 0.79 respectively.

4.2.3 Body girth

The fortnightly body girth of non-transported and transported pigs of halothane positive and negative groups are presented (Table 3).

The girth at 210 days of age for nontransported halothane negative and positive animals were 92.5 ± 2.72 cm and 89.67 ± 2.7 cm, and for transported halothane negative and positive animals were 94.2 ± 1.99 cm and 93.17 ± 3.02 cm. These differences in girth were non-significant.

The overall mean for halothane resistant group was 93.44 ± 1.56 cm and for sensitive group was 91.42 ± 2.00 cm.

4.3 Feed efficiency

In the case of non-transported halothane negative and positive genotypes the feed efficiency was 4.04 ± 0.37 and 4.18 ± 0.37 respectively (Table 4) (Fig. 3). For transported pigs, the feed efficiency of

Table 3. (a) Fortnightly body girth (cm)

Age in fortnights	Non-transported		Transported	
	Hal-	Hal+	Hal-	Hal+
Initial	43.66	44.16	42.50	45.00
1	47.00	47.50	45.00	48.00
2	51.50	51.00	49.00	52.00
3	56.20	54.00	53.00	54.83
4	64.60	64.33	63.50	67.00
5	70.00	67.83	68.00	68.00
6	78.00	74.08	74.00	75.33
7	82.40	77.67	80.80	79.33
8	88.40	88.83	88.00	82.83
9	90.80	90.67	91.10	86.17
10	94.20	93.17	92.50	89.67

(b) Girth at 210 days (cm) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	92.50 ± 2.72	94.20 ± 1.99	93.44 ± 1.56
Hal+	89.67 ± 2.70	93.17 ± 3.02	91.42 ± 2.00
Mean	90.80 ± 1.91	93.64 ± 1.80	92.29 ± 1.31

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	2107.28	2107.28	2.01 NS
Between transport	1	56252.78	56252.78	2.01 NS
Interaction	1	357.33	357.33	0.34 NS
Error	42	43983.88	1047.235	

Table 4. (a) Feed conversion efficiency (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	4.04 ± 0.37	3.57 ± 0.22	3.78 ± 0.22
Hal+	4.18 ± 0.37	4.13 ± 0.29	4.15 ± 0.23
Mean	4.12 ± 1.45	3.38 ± 0.20	3.99 ± 23.2

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	4.04	3.57	1.1407	NS
NT+ Vs T+	4.18	4.13	0.1023	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	0.664	0.664	1.21 NS
Between transport	1	0.269	0.269	1.21 NS
Interaction	1	0.225	0.225	0.41 NS
Error	17	9.312	0.548	

Fig. 2 FORTNIGHTLY RATE OF GAIN IN WEIGHT OF PIGS

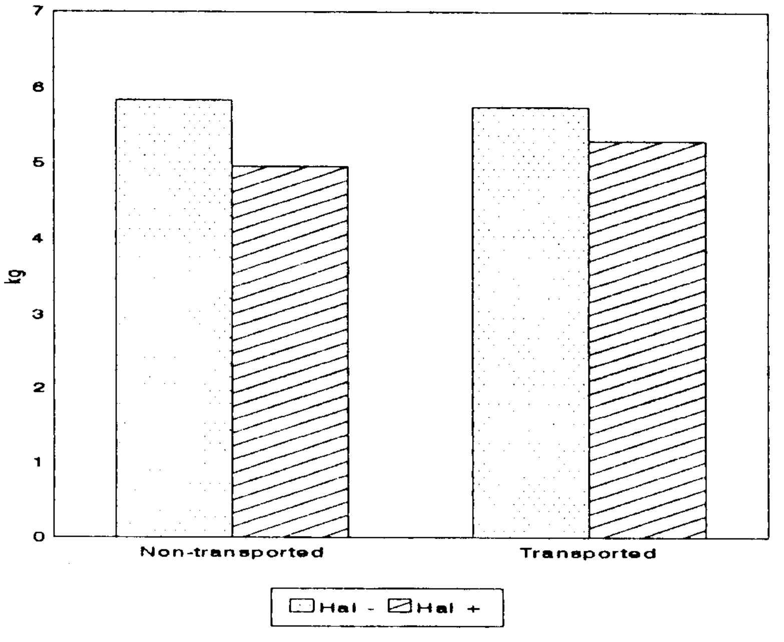
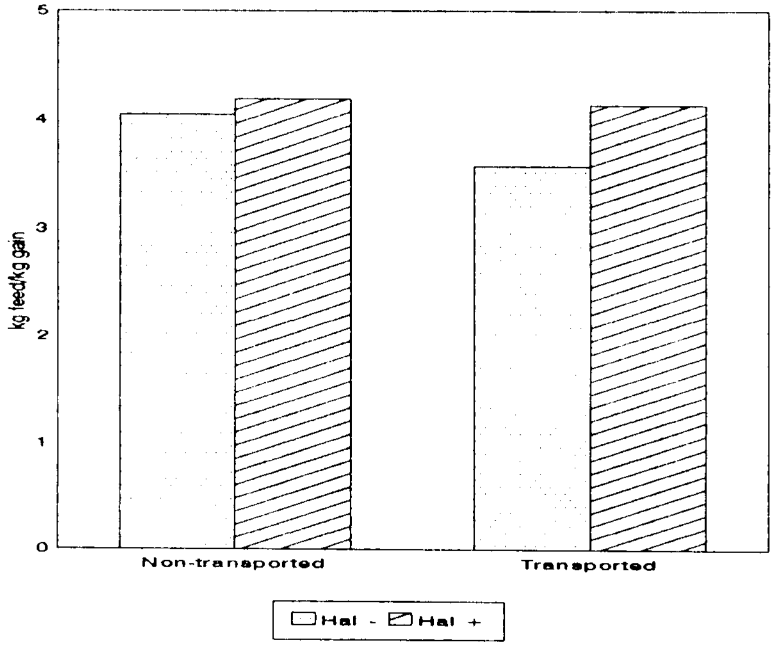


Fig.3 FEED EFFICIENCY OF PIGS



negative and positive animals were 3.57 ± 0.22 kg and 4.13 ± 0.29 kg. The difference being non-significant.

The overall mean feed efficiency for halothane negative animals was 3.78 ± 0.22 and for halothane positive animals was 4.15 ± 0.23.

4.4 Haematological changes

4.4.1 Blood pH

For non-transported halothane negative and positive animals the mean pH values were 7.33 ± 0.13 and 7.18 ± 0.09 and for transported animals the values were 7.41 ± 0.08 and 7.45 ± 0.07 respectively. The overall mean for halothane negative genotype was 7.36 ± 0.06 and for halothane positive genotype was 7.28 ± 0.04. The difference between the transported and non-transported groups and between the genotypes were non-significant (Table 5).

4.4.2 Erythrocyte sedimentation rate (ESR)

The average ESR value of transported and non-transported animals of both halothane genotypes are presented in Table 6.

In the case of non-transported animals the mean ESR values were 17.18 ± 3.63 mm/hr and 8.50 ± 1.72 mm/hr and for transported animals the values were 22.67 ± 2.75 mm/hr and 21.22 ± 3.14 mm/hr for halothane negative and positive respectively.

The difference between the two genotypes and the

Table 5. (a) Blood pH (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	7.33 ± 0.13	7.41 ± 0.08	7.36 ± 0.06
Hal+	7.18 ± 0.09	7.45 ± 0.07	7.28 ± 0.04
Mean	7.26 ± 0.05	7.43 ± 0.04	7.32 ± 0.04

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	7.33	7.41	1.0057	NS
NT+ Vs T+	7.18	7.45	3.0833	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	0.110	0.110	2.23 NS
Between transport	1	0.395	0.395	2.23 NS
Interaction	1	0.114	0.114	2.30 NS
Error	57	2.825	0.050	

Table 6. (a) Erythrocyte Sedimentation Rate (mm/hr) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	17.18 ± 3.63	22.67 ± 2.75	20.04 ± 2.28
Hal+	8.50 ± 1.72	21.22 ± 3.14	15.24 ± 2.40
Mean	13.53 ± 2.40	22.05 ± 2.02	18.00 ± 1.68

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	17.18	22.65	1.2164	NS
NT+ Vs T+	8.50	21.22	3.4270	*

* Significant P<0.05

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	232.186	232.186	2.51 NS
Between transport	1	730.512	730.512	2.51 NS
Interaction	1	127.645	127.645	1.38 NS
Error	36	3325.859	92.385	

transported and non-transported animals were non-significant. But, the transported halothane sensitive animals had a significantly higher ESR value than the nontransported halothane sensitive animals.

4.4.3 Packed cell volume (PCV)

The mean PCV value of non-transported and transported, animals of both genotypes are presented in Table 7.

The average PCV values for non-transported halothane negative and positive animals were 33.18 ± 1.84 percent and 35.13 ± 0.99 percent. The mean PCV values for transported animals were 29.67 ± 2.14 percent and 34.56 ± 0.44 percent for halothane negative and positive animals.

The difference in PCV values were nonsignificant for both genotypes and for transported and non-transported animals.

4.4.4 Lactate dehydrogenase (LDH)

The mean ± SE values of LDH did not vary significantly between transported and non-transported animals and between the two genotypes. The average values of halothane negative and positive animals were 112.96 ± 11.59 and 127.23 ± 14.04 IU/L. The mean LDH values for transported and non-transported animals were 117.23 ± 14.85 and 122.15 ± 14.51 IU/L (Table 8) (Fig. 4).

4.4.5. Creatine phosphokinase (CPK)

The mean ± SE of CPK for halothane negative and positive

Table 7. (a) Packed cell volume (PCV) (percentage) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	33.18 ± 1.84	29.67 ± 2.14	31.35 ± 1.47
Hal+	35.13 ± 0.99	34.56 ± 0.44	34.82 ± 1.97
Mean	34.00 ± 1.13	31.76 ± 6.98	32.83 ± 0.91

(b) Test of significance

Group	Mean		t-value	Remarks
NT- Vs T-	33.18	29.67	-1.2338	NS
NT+ Vs T+	35.13	34.56	-0.5460	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	119.264	119.264	4.10 NS
Between transport	1	51.142	51.142	4.10 NS
Interaction	1	21.146	21.146	0.73 NS
Error	36			

Table 8. (a) Lactate dehydrogenase (IU/L) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	105.80 ± 10.08	122.98 ± 24.52	112.96 ± 11.59
Hal+	136.45 ± 20.06	110.84 ± 16.02	127.23 ± 14.04
Mean	122.15 ± 14.51	117.23 ± 14.85	120.24 ± 9.02

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	105.8	122.98	0.6481	NS
NT+ Vs T+	136.45	110.84	-0.8692	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	2406.347	2406.347	0.58 NS
Between transport	1	193.167	193.167	0.58 NS
Interaction	1	5307.099	5307.099	1.27 NS
Error	45	187617.063	4169.268	

animals were 158 ± 15.36 and 199.90 ± 15.28 IU/L respectively. For non-transported and transported pigs the values were 170.12 ± 20.32 and 183.85 ± 15.16 IU/L. There was significant difference in CPK values between the two genotypes and between the non-transported and transported groups (Table 9) (Fig. 5).

4.5 Carcass traits

4.5.1 Live weight of pigs at slaughter and shrinkage

Live weight of pigs at slaughter are presented treatment-wise and genotype-wise (Table 10) (Fig. 6).

The average slaughter weight of non-transported halothane negative and positive pigs were 66.25 ± 5.45 kg and 63.0 ± 5.43 kg and the overall mean 64.3 ± 3.75 kg and for transported animals the mean slaughter weights of halothane negative and positive pigs were 65.2 ± 4.34 kg and 57.33 ± 3.55 kg respectively and the overall mean 60.91 ± 2.89 kg.

In the case of halothane negative and positive pigs the average slaughter weight were 65.67 ± 3.19 kg and 60.17 ± 3.21 kg respectively.

The difference between all the groups were non-significant.

The body weights of animals were taken just before and after transportation at 90 days of age and 210 days of age. Though the body weights did not differ significantly between halothane negative and positive groups before and after transportation the loss of weight due

Fig.4 SERUM LACTATE DEHYDROGENASE

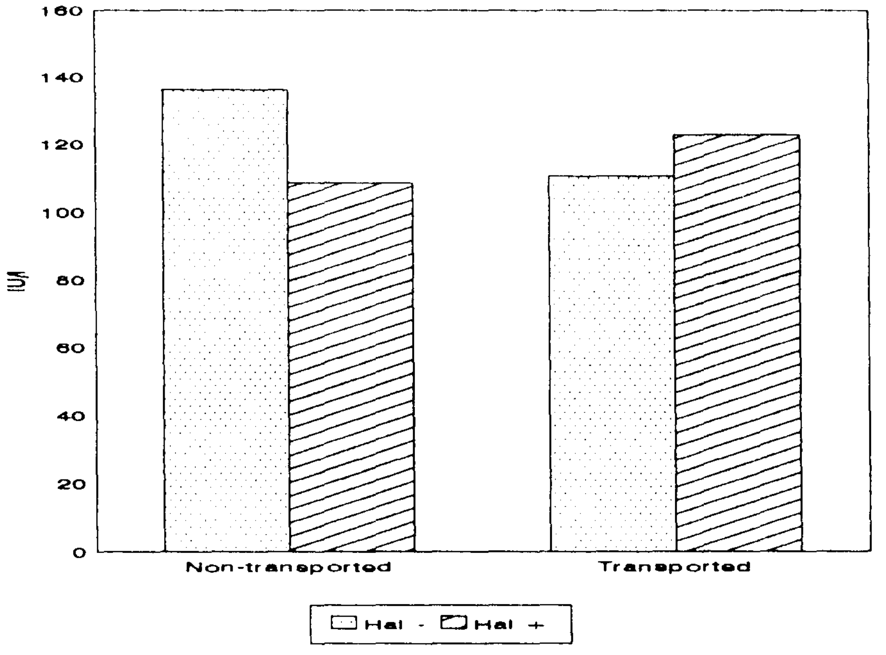


Fig.5 SERUM CREATINE PHOSPHOKINASE

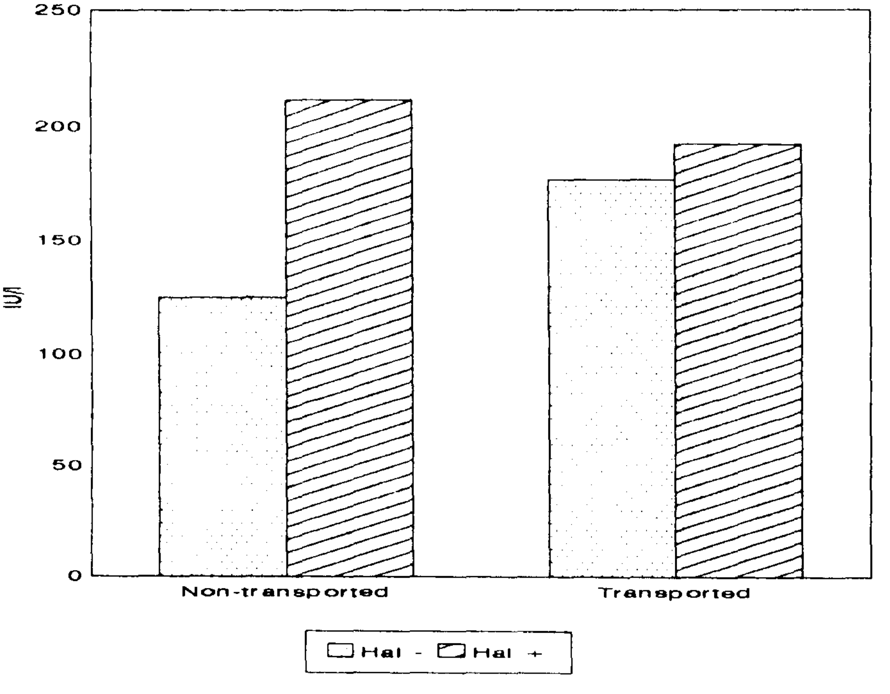


Table 9. (a) Serum creatine phosphokinase (IU/L) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	124.73 ± 22.87	176.71 ± 17.95	158.00 ± 15.36
Hal+	210.97 ± 27.29	192.00 ± 17.16	199.90 ± 15.28
Mean	170.12 ± 20.32	183.85 ± 15.16	178.52 ± 11.66

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	124.73	176.71	-1.7650	NS
NT+ Vs T+	210.97	192.00	0.6183	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	22384.983	22384.983	4.28 *
Between transport	1	3075.427	3075.427	4.28 *
Interaction	1	14590.188	14590.188	2.79
Error	45	235555.501	4234.567	

* Significant at 5% level P<0.05

Table 10. (a) Slaughter weight of pigs (kg) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	66.25 ± 5.45	65.20 ± 4.34	65.67 ± 3.19
Hal+	63.00 ± 5.43	57.33 ± 3.55	60.17 ± 3.21
Mean	64.30 ± 3.75	60.91 ± 2.89	62.52 ± 2.31

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	66.25	65.20	0.1533	NS
NT+ Vs T+	63.00	57.33	0.8746	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	166.917	166.917	1.43 NS
Between transport	1	71.574	71.574	1.43 NS
Interaction	1	27.209	27.209	0.23 NS
Error	17	1988.883	116.993	

to transport showed significant difference between the two groups at 90 days of age (Table 11) (Fig. 7). The halothane resistant pigs had a higher loss in body weight than sensitive pigs, the mean loss in body weight for halothane sensitive pigs were 1.083 ± 0.24 kg and for resistant pig were 2.00 ± 0.22 kg. The percentage body weight lost were 6.847 ± 1.32 and 11 ± 0.503 respectively.

At 210 days of age, the loss in body weight was non-significant. The halothane negative animals lost 5.1 ± 0.4 kg and halothane positive pigs lost 3.417 ± 0.61 kg. The percentage loss in body weight were 7.206 ± 0.813 for halothane resistant and 5.328 ± 0.82 for halothane sensitive animals.

4.5.2 Carcass length and dressing percentage

In the case of nontransported halothane negative and positive pigs the average dressed weight after beheading were 47.75 ± 4.72 kg and 46.83 ± 4.26 kg respectively (Table 12) (Fig. 8). For transported pigs, the halothane negative and positive pigs had a mean weight of 48.8 ± 3.84 kg and 44.83 ± 2.54 kg. The differences between the halothane genotypes and between transported and non-transported animals were insignificant.

For non-transported halothane negative and positive animals the mean carcass length was 76.00 ± 2.1 cm and 75.50 ± 1.84 cm and the overall mean 75.70 ± 1.31 cm. In the case of transported animals, the mean for halothane negative and positive were 74.70 ± 1.52 cm and 71.17 ± 1.03 cm and their mean 72.77 ± 1.00 cm. There

Fig.6 SLAUGHTER WEIGHT OF PIGS

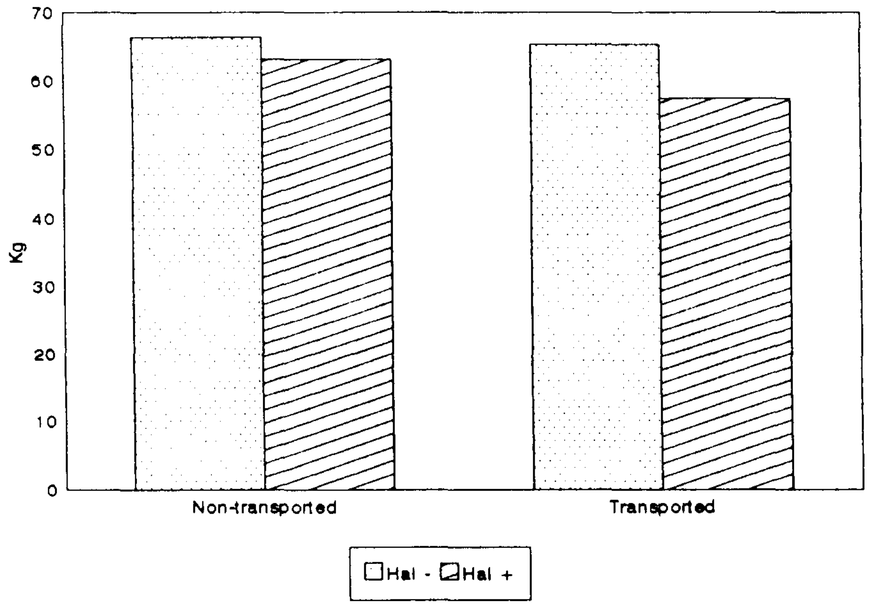


Fig.7 SHRINKAGE DURING TRANSPORT

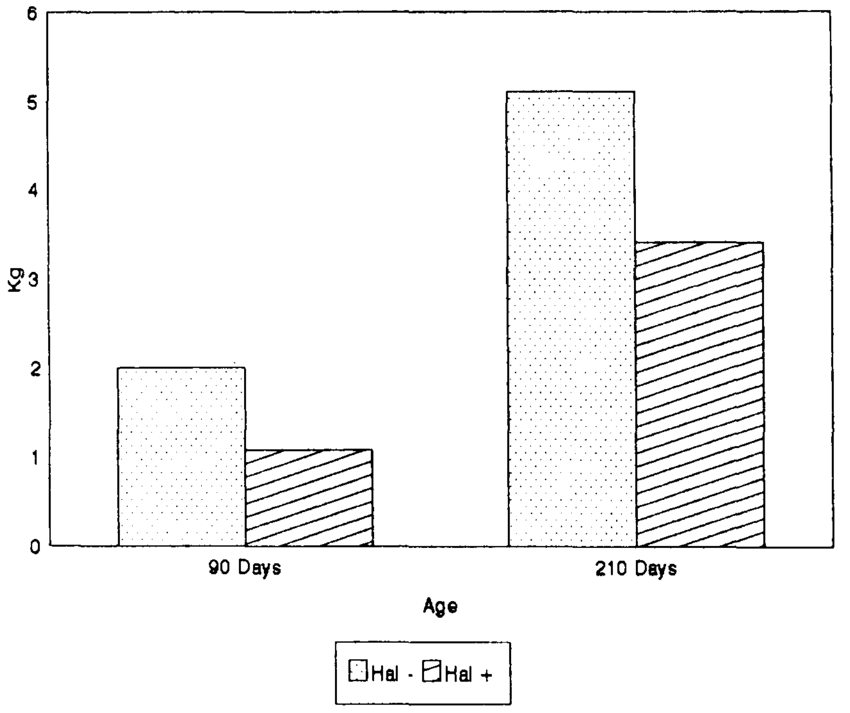


Table 11. (a) Shrinkage during transport (Mean±SE)

Age	90 days		210 days	
genotype	Hal-	Hal+	Hal-	Hal+
Body weight before transport (kg)	18.00± 1.41	15.42± 0.76	72.30± 4.71	63.92± 3.69
Body weight after transport (kg)	16.00± 1.20	14.33± 0.63	67.20± 4.85	60.50± 3.47
Weight loss (kg)	2.00± 0.22	1.08± 0.24	5.10± 0.40	3.41± 0.61
% body weight lost	11.00± 0.50	6.84± 1.32	7.20± 0.81	5.32± 0.82

(b) Test of significance
Body weight at 90 days of age

Hal+ Vs Hal-	Means		t value	Remarks
Before transport (kg)	15.42	18.00	-1.6921	NS
After transport (kg)	14.33	16.00	-1.2922	NS
Difference (kg)	1.083	2.00	-2.7596	*
Percentage weight loss	6.85	11.00	-2.7258	*

(c) Body weight at 210 days of age

Hal+ Vs Hal-	Means		t value	Remarks
Before transport (kg)	63.917	72.3	-1.4229	NS
After transport (kg)	60.50	67.20	-1.1506	NS
Difference (kg)	3.417	5.10	-2.1971	NS
Percentage weight loss	5.328	7.206	-1.6064	NS

* Significant at 1% level

Table 12. (a) Carcass length (cm) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	76.00 ± 2.10	74.70 ± 1.52	75.28 ± 1.20
Hal+	75.50 ± 1.84	71.17 ± 1.03	73.33 ± 1.19
Mean	75.70 ± 1.31	72.77 ± 1.00	74.17 ± 0.86

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	76.00	74.70	-0.5132	NS
NT+ Vs T+	75.50	71.17	-2.0791	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	22.902	22.902	1.69 NS
Between transport	1	48.343	48.343	1.69 NS
Interaction	1	11.746	11.746	0.87 NS
Error	17	230.133	13.537	

was no significant difference between transported and non-transported groups or between the genotypes (Table 13).

Dressing percentage of non-transported and transported pigs of both halothane genotypes are presented in Table 14, (Fig. 9). The non-transported halothane negative and positive pigs had a dressing percentage of 71.73 ± 1.52 and 74.18 ± 1.26 and for transported pigs the values were 76.18 ± 0.78 and 78.48 ± 2.57 respectively.

The overall mean for halothane negative pigs was 74.20 ± 1.08 and for halothane positive pigs it was 76.33 ± 1.51.

4.5.3 Meat pH

The average pH of meat of non-transported halothane negative and positive animals were 6.52 ± 0.079 and 5.81 ± 0.06, and that of transported pigs were 5.72 ± 0.08 and 5.56 ± 0.21 respectively. The mean of halothane negative genotype was 6.07 ± 0.15 and for halothane positive genotype was 5.69 ± 0.11 (Table 15) (Fig. 10).

The meat pH of non-transported halothane negative pigs varied significantly from the meat pH of transported halothane negative and positive pigs.

There was significant difference in meat pH between the two halothane genotypes and between the transported and non-transported groups.

Fig.8 CARCASS LENGTH

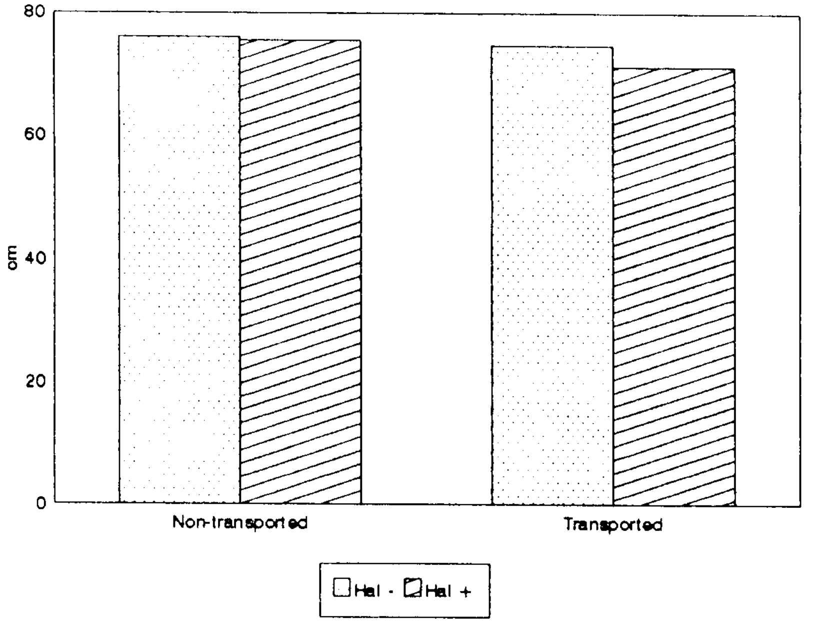


Fig.9 DRESSING PERCENTAGE OF CARCASS

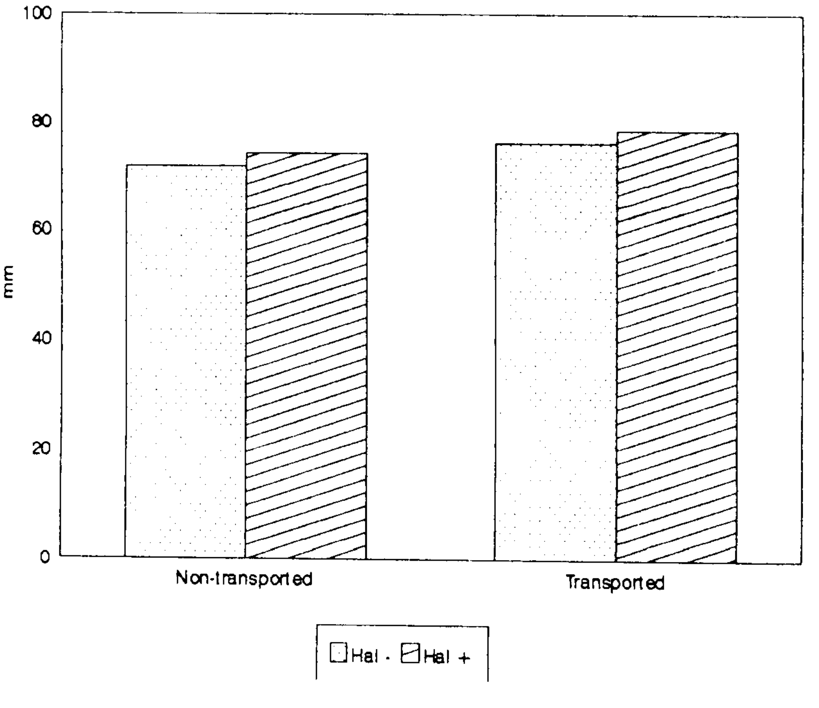


Table 13. (a) Dressed weight after beheading (kg) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	47.75 ± 4.72	48.80 ± 3.84	48.89 ± 2.82
Hal+	46.83 ± 4.26	44.83 ± 2.54	45.83 ± 2.38
Mean	47.20 ± 3.01	47.09 ± 4.52	47.14 ± 1.81

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	47.75	48.8	-0.3412	NS
NT+ Vs T+	46.83	44.83	0.4033	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	48.353	48.353	0.63 NS
Between transport	1	0.400	0.400	0.63 NS
Interaction	1	20.939	20.939	0.27 NS
Error	17	1299.217	76.425	

Table 14. (a) Dressing percentage (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	71.73 ± 1.52	76.18 ± 0.78	74.20 ± 1.08
Hal+	74.18 ± 1.26	78.48 ± 2.57	76.33 ± 1.51
Mean	73.20 ± 1.00	77.44 ± 1.43	75.42 ± 0.99

(b) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	28.819	28.819	1.72 NS
Between transport	1	99.714	99.714	1.72 NS
Interaction	1	0.029	0.029	0.003 NS
Error	17	284.949	16.762	

Table 15. (a) Meat pH (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	6.52 ± 0.079	5.72 ± 0.08	6.07 ± 0.15
Hal+	5.81 ± 0.06	5.56 ± 0.21	5.69 ± 0.11
Mean	6.10 ± 0.12	5.63 ± 1.70	5.85 ± 0.10

(b) Test of significance

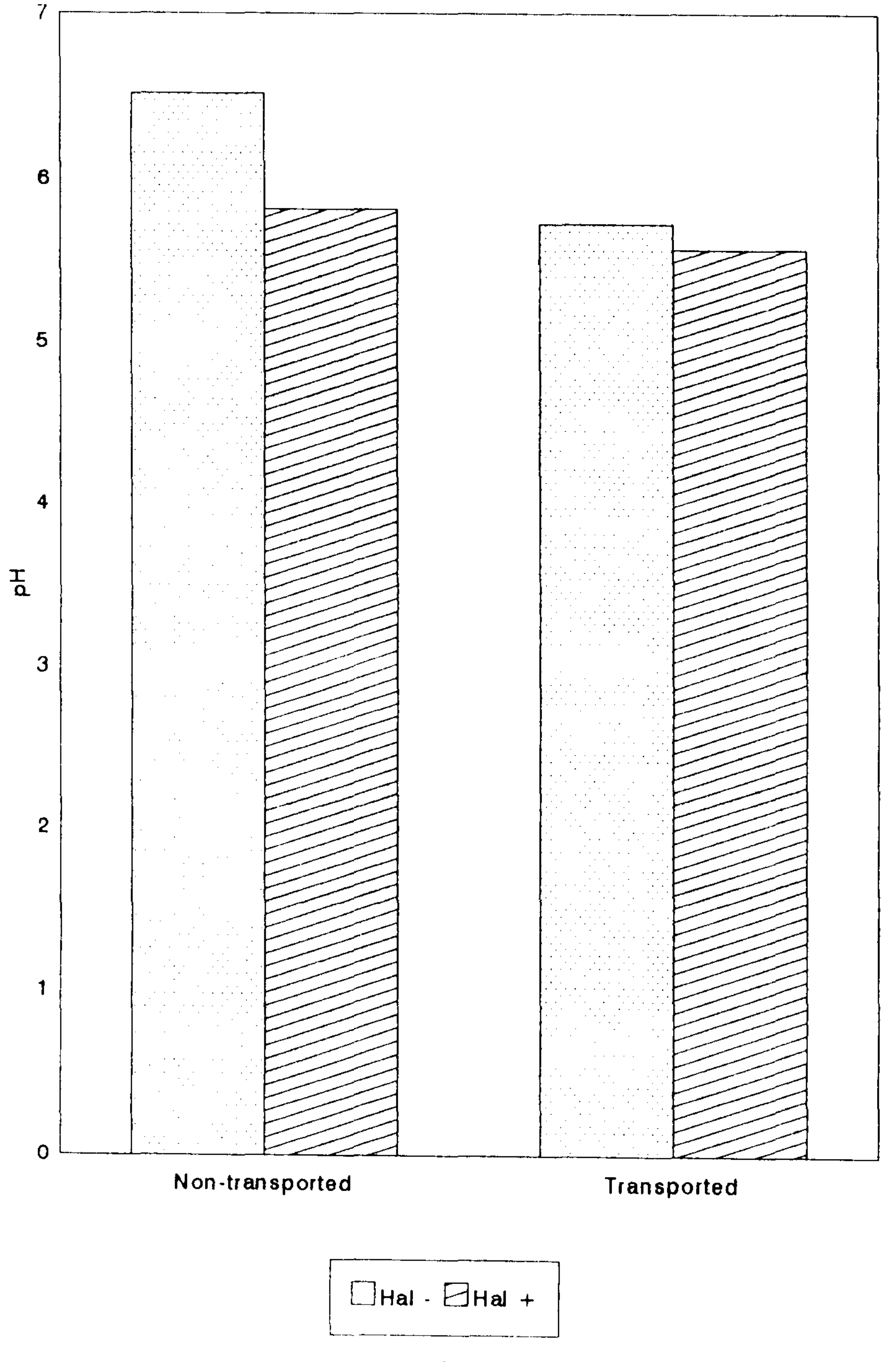
Group	Mean		t value	Remarks
NT- Vs T-	6.52	5.72	7.0880	**
NT+ Vs T+	5.81	5.56	1.1636	NS
T- Vs T+	5.72	5.56	0.6373	NS
NT- Vs T+	6.52	5.56	3.6090	**

** Highly significant P<0.01

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	0.875	0.875	9.38 **
Between transport	1	0.238	1.238	9.38 **
Interaction	1	0.395	0.395	4.24 NS
Error	17	1.586	0.093	

Fig. 10 MEAT pH OF PIGS



4.5.4 Loin eye area

The mean loin eye area for non-transported and transported, halothane negative and positive animals are presented in Table 16 (Fig. 11).

In the case of non-transported, halothane negative and positive animals the average loin eye areas were 25.94 ± 2.87 cm^2 and 27.82 ± 1.52 cm^2, and for transported animals 23.80 ± 1.12 cm^2 and 20.46 ± 0.57 cm^2 respectively. The overall mean for nontransported and transported animals were 27.06 ± 1.4 cm^2 and 21.98 ± 0.77 cm^2 and for halothane negative and positive animals were 24.75 ± 1.37 cm^2 and 24.14 ± 1.35 cm^2 respectively. The differences between the transported and non-transported animals, and between the genotypes were non-significant.

4.5.5 Backfat thickness

For non-transported halothane negative and positive pigs, the backfat thickness measured were 26.4 ± 0.23 mm and 23.5 ± 0.18 mm, and in the case of transported pigs the backfat thickness for halothane negative and positive pigs were 25.5 ± 0.27 mm and 29.1 ± 0.3 mm respectively (Table 17) (Fig. 12).

The overall mean for non-transported and transported animals were 24.6 ± 0.142 mm and 27.7 ± 0.2 mm. The differences between transportation treatments and between the two genotypes were non-significant.

Table 16. (a) Loin eye area (cm^2) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	25.94 ± 2.87	23.80 ± 1.12	24.75 ± 1.37
Hal+	27.82 ± 1.52	20.46 ± 0.57	24.14 ± 1.35
Mean	27.06 ± 1.40	21.98 ± 0.77	24.40 ± 0.95

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	25.94	23.80	-0.7568	NS
NT+ Vs T+	27.82	20.46	-4.5199	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	4.133	4.133	0.35 NS
Between transport	1	137.792	137.792	0.35 NS
Interaction	1	34.796	34.796	2.91 NS
Error	17	203.607	11.977	

Fig.11 LOIN EYE AREA

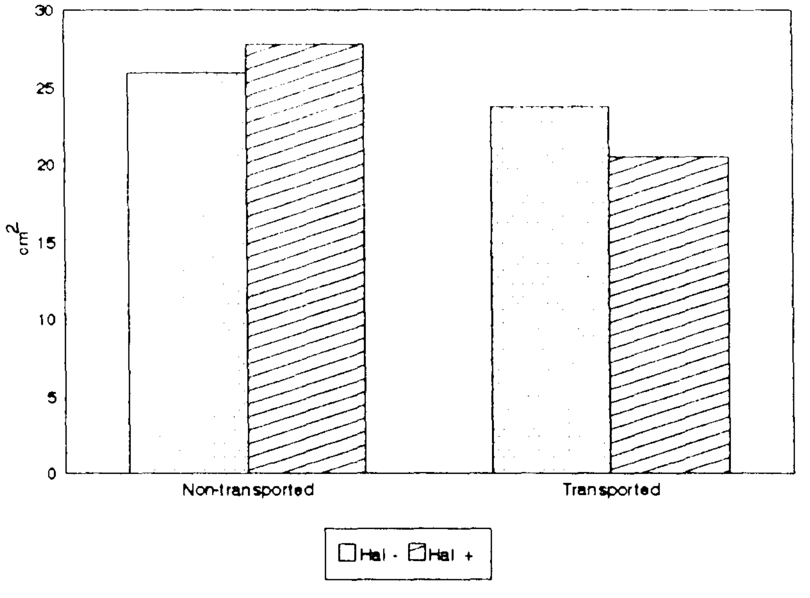


Fig.12 BACKFAT THICKNESS OF PIGS

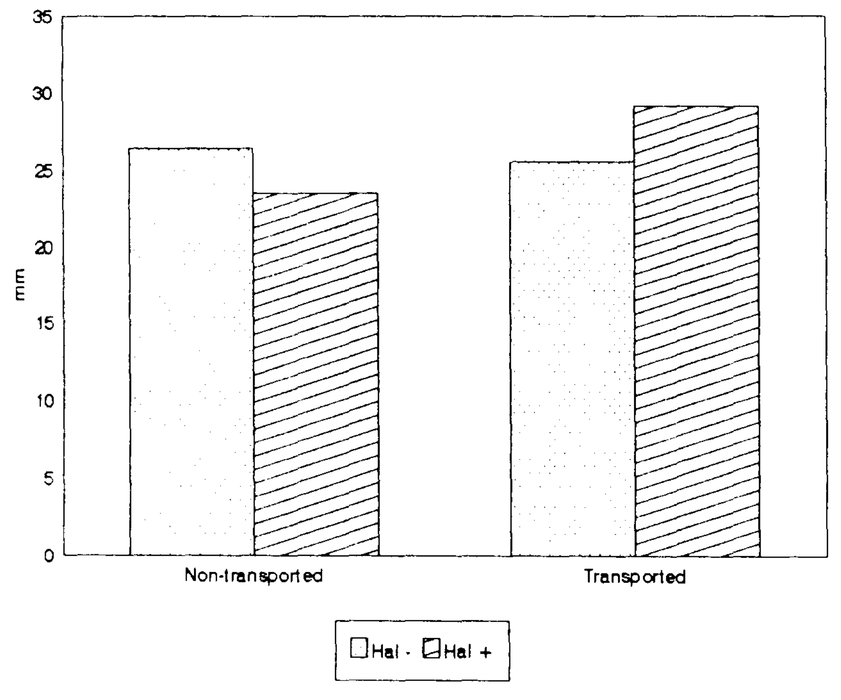


Table 17. (a) Backfat thickness (mm) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	26.48 ± 0.23	25.50 ± 0.27	25.90 ± 0.17
Hal+	23.50 ± 0.18	29.10 ± 0.30	26.30 ± 0.19
Mean	**24.60 ± 0.14**	**27.70 ± 0.20**	**26.10 ± 0.13**

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	26.4	25.5	-1.6075	NS
NT+ Vs T+	23.5	29.1	-0.3412	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	0.014	0.014	0.04 NS
Between transport	1	0.411	0.411	0.04 NS
Interaction	1	0.544	0.544	1.63 NS
Error	17	5.663	0.333	

4.5.6 Organ weights

The average weights of heart, liver, lungs, kidney, spleen, stomach and intestines are presented treatment-wise and genotype-wise in Tables 18 to 22.

4.5.6.1 Heart

The mean heart weights of non-transported halothane negative and positive pigs were 195.0 ± 12.6 g and 210.0 ± 9.68 g and their mean 204 ± 7.63 g. The average heart weights of transported halothane negative and positive pigs and their means were 192 ± 11.58 g, 179 ± 10.74 g and 185.09 ± 7.73 g respectively (Table 18).

The overall mean heart weights of halothane negative pigs and positive were 193 ± 7.99 g and 194.67 ± 8.29 g respectively.

4.5.6.2 Liver

In the case of non-transported pigs the mean weights of liver of halothane negative and positive genotypes were 1.17 ± 0.1 kg and 1.11 ± 0.08 kg. For the transported pigs the average weights of liver of negative and positive genotypes were 1.13 ± 0.047 kg and 1.09 ± 0.052 kg (Table 19).

4.5.6.3 Kidney

In the case of nontransported pigs the weights of kidneys of halothane negative and positive pigs were 185 ± 29.58 g and 165 ± 16.28 g

Table 18 (a) Weight of heart (g) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	195.00 ± 12.6	192.00 ± 11.58	193.00 ± 7.99
Hal+	210.00 ± 9.68	179.00 ± 10.74	194.67 ± 8.29
Mean	204.00 ± 7.63	185.09 ± 7.73	194.10 ± 5.71

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	195	192	0.1748	NS
NT+ Vs T+	210	179	0.21241	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	0.413	0.413	0.003 NS
Between transport	1	1864.17	1864.17	0.004 NS
Interaction	1	977.163	977.163	1.530 NS
Error	17	10833.33	637.255	

Table 19. (a) Weight of liver (kg) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	1.17 ± 0.10	1.09 ± 0.04	1.13 ± 0.05
Hal+	1.11 ± 0.08	1.08 ± 0.08	1.09 ± 0.05
Mean	1.13 ± 0.06	1.09 ± 0.04	1.11 ± 0.04

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	1.17	1.09	0.7314	NS
NT+ Vs T+	1.11	1.08	0.2618	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	0.006	0.006	0.2 NS
Between transport	1	0.11	0.11	0.2 NS
Interaction	1	0.002	0.002	0.8 NS
Error	17	0.499	0.029	

The mean kidney weights of transported halothane negative and positive pigs were 158 ± 14.63 g and 146.67 ± 8.03 g respectively (Table 20).

The means of non-transported animals were 173 ± 14.69 g and that of transported pigs were 151.82 ± 7.73 g. The average for halothane negative and positive pigs were 170 ± 15.09 g and 155.83 ± 9.08 g. The overall mean was 161.9 ± 8.21 g.

4.5.6.4 Spleen

For non-transported pigs the mean weights of spleen of halothane negative and positive genotypes were 75 ± 8.66 g and 93.33 ± 6.67 g with an overall average of 86.00 ± 5.81 g (Table 21).

For transported pigs the average spleen weights of negative and positive genotypes were 88 ± 6.26 g and 70 ± 8.56 g with an overall mean of 78.18 ± 6.00 g.

4.5.6.5 Stomach and intestines

The mean weights of stomach and intestines of halothane negative and positive, non-transported pigs were 8.25 ± 0.78 kg and 7.83 ± 0.803 kg. In the case of transported animals, the halothane negative and positive pigs had an average weights of 7.2 ± 0.2 kg and 6.5 ± 0.45 kg respectively (Table 22).

4.5.6.6 Meat

In the case of non-transported halothane negative and

Table 20. (a) Weight of kidney (g) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	185.00 ± 29.58	158.00 ± 14.63	170.00 ± 15.09
Hal+	165.00 ± 16.28	146.67 ± 8.03	155.83 ± 9.08
Mean	173.00 ± 14.69	151.82 ± 7.73	161.90 ± 8.21

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	185	158	0.8759	NS
NT+ Vs T+	165	146	1.0101	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	1214.417	1214.417	0.84 NS
Between transport	1	2532.447	2532.447	0.84 NS
Interaction	1	95.887	95.887	0.07 NS
Error	17	24663.33	1450.78	

Table 21. (a) Weight of spleen (g) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	75.00 ± 8.66	88.00 ± 6.26	82.22 ± 5.47
Hal+	93.33 ± 6.67	70.00 ± 8.56	81.67 ± 6.26
Mean	86.00 ± 5.81	78.18 ± 6.00	81.90 ± 4.18

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	75	88	-1.2153	NS
NT+ Vs T+	93	70	2.15	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	5.055	5.055	0.004
Between transport	1	323.641	323.641	0.19
Interaction	1	1685.248	1685.248	5.39
Error	17	5313.333	312.549	

Table 22. (a) Weight of stomach and intestines (kg) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	8.25 ± 0.78	7.20 ± 0.20	7.67 ± 0.38
Hal+	7.83 ± 0.80	6.50 ± 0.45	7.23 ± 0.51
Mean	8.00 ± 0.55	6.85 ± 0.26	7.43 ± 0.32

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	8.25	7.2	1.3082	NS
NT+ Vs T+	7.83	6.5	1.3675	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	1.543	1.543	0.79 NS
Between transport	1	7.2	7.2	0.79 NS
Interaction	1	0.098	0.098	0.05 NS
Error	16	31.383	1.961	

positive animals the average weight of meat in the carcass was 39.38 ± 4.97 kg and 38 ± 3.47 kg with a mean of 38.55 ± 2.59 kg. For transported pigs, the halothane resistant and sensitive animals had an average of 39.8 ± 4.14 kg and 34.08 ± 2.79 kg with an overall mean of 36.68 ± 4.81 kg (Table 23).

The average weight of meat for halothane negative animals were 39.61 ± 2.85 kg and for positive pigs were 36.04 ± 2.2 kg.

The meat-bone ratio for non-transported halothane negative and positive animals were 7.11 ± 0.67 and 6.7 ± 0.316, and for transported animals were 7.04 ± 0.57 and 6.52 ± 0.52 respectively. The overall mean for halothane negative animals was 7.07 ± 0.41 and for halothane positive animals was 6.6 ± 0.31 (Table 24).

4.5.7 Crude fat content of liver and kidney

The lipid content of liver and kidney were analysed as percentage of dry matter. For non-transported group, the total lipid content of liver of halothane negative and positive genotypes were 13.49 ± 2.22 per cent and 14.71 ± 1.01 per cent dry matter. For transported animals the lipid content of liver of halothane negative and positive genotypes were 15.45 ± 1.143 percent and 11.12 ± 1.55 percent respectively (Table 25).

In the case of kidney, the total lipid content of non-transported, halothane negative and positive animals were 15.5 ± 1.92 per cent and 12.81 ± 1.63 per cent on dry matter basis. For the transported pigs the values were 14.02 ± 2.41 per cent and 15.23 ± 1.18 per cent respectively (Table 25).

For both liver and kidney, the total lipid contents of the different treatment groups did not differ significantly.

Table 23. (a) Weight of meat (kg) (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	39.38 ± 4.47	39.80 ± 4.14	39.61 ± 2.85
Hal+	38.00 ± 3.47	34.08 ± 2.79	36.04 ± 2.20
Mean	38.55 ± 2.59	36.68 ± 4.81	37.57 ± 1.75

(b) Test of significance

Group	Mean		t value	Remarks
NT- Vs T-	39.38	39.80	-0.0695	NS
NT+ Vs T+	38.00	34.08	0.8793	NS

(c) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	69.602	69.602	1.00 NS
Between transport	1	22.358	22.358	1.00 NS
Interaction	1	24.064	24.064	0.35 NS
Error	17	1177.696	69.276	

Table 24. (a) Meat - Bone ratio (Mean±SE)

Genotype	Non-transport	Transport	Mean
Hal-	7.11 ± 0.67	7.04 ± 0.57	7.07 ± 0.41
Hal+	6.70 ± 0.32	6.52 ± 0.52	6.60 ± 0.31
Mean	6.88 ± 0.33	6.78 ± 0.38	6.81 ± 2.01

(b) ANOVA

Source	df	SS	MS	F
Between halothane genotypes	1	1.087	1.087	0.78 NS
Between transport	1	0.087	0.087	0.78 NS
Interaction	1	0.013	0.013	0.01 NS
Error	16	22.158	1.385	

Table 25. (a) Chemical composition of kidney and liver (Mean±SE)

Organ	Chemical composition	Non-transported		Transported	
		Hal-	Hal+	Hal-	Hal+
Kidney	Moisture	77.86± 0.42	77.33± 0.58	76.99± 0.95	78.18± 0.92
	Drymatter (DM)	22.14± 0.42	22.67± 0.58	23.01± 0.95	21.82± 0.92
	Total lipids (% DM)	15.50± 1.92	12.81± 1.63	14.02± 0.33	15.23± 1.18
Liver	Moisture	68.60± 0.69	69.52± 0.42	69.02± 0.33	68.97± 0.62
	Drymatter (DM)	31.20± 0.69	30.48± 0.42	30.98± 0.33	31.03± 0.62
	Total lipids (% DM)	13.49± 2.22	14.71± 1.01	15.45± 1.14	11.12± 1.55

(b) Test of significance

Organ	Group	Mean		t value	Remarks
Kidney	NT- Vs T-	15.50	14.02	-0.4613	NS
	NT+ Vs T+	12.81	15.23	1.2032	NS
Liver	NT- Vs T-	13.49	15.45	0.8384	NS
	NT+ Vs T+	14.71	11.12	-1.9436	NS

c.(1) ANOVA for total lipids in kidney

Source	df	SS	MS	F
Between halothane genotypes	1	1.963	1.963	0.12 NS
Between transport	1	3.005	3.005	0.12 NS
Interaction	1	19.420	19.420	1.17 NS
Error	17	281.751	16.574	

c. (2) ANOVA for total lipids in liver

Source	df	SS	MS	F
Between halothane genotypes	1	15.391	15.391	1.39 NS
Between transport	1	7.857	7.857	1.39 NS
Interaction	1	39.379	39.379	3.57 NS
Error	17	187.714	11.042	

DISCUSSION

5. DISCUSSION

5.1. Behaviour

The halothane negative groups exhibited more investigatory behaviour and most of the animals were moving about the pen in the morning hours, whereas the positive animals huddled together. These were against the findings of Shaefer et al. (1989) who reported that halothane positive pigs spent longer time for investigating in their pen and they slept less frequently in groups. The halothane negative animals were more aggressive, and the incidences of tail biting and bruises were more for this group. This was comparable to the finding of Shaefer et al. (1989).

During both transportations at 90 days and 210 days of age, fighting was rare during movement. But, when the vehicle stopped after two hour of transport, fighting was observed. The negative pig attacked more frequently the positive animals and vigorous fighting occurred within few minutes. This was supported by Pearson and Kilgour (1980). Mixing resulted in fighting between the two genotypes during transport. This agrees with the reports of Sather et al. (1995), that the mixed pigs accounted for 75 per cent of aggressive activity. During transportation at 210 days of age, it was observed that the pigs were lying after one hour and continued in that posture during the rest of transportation. This was comparable with the reports of Geers et al. (1994). After the transportation eventhough the animals were released into a new environment, no activity was observed and all were lying in the wallowing tank with little activity. These were against the findings of Wood et al. (1990) where the activity was higher for animals after release to a semi-natural environment.

5.2. Growth performance

The weaning weights of halothane negative and positive pig in this study did not differ significantly. Similarly, Rundgen et al. (1990a) reported no significant difference in piglet weight at birth and at three, six and nine weeks.

By seven months, the non-transported halothane negative animals had the highest average body weight of 66 ± 2.12 kg, followed by transported halothane negative group having 65.5 ± 2.47 kg. The halothane sensitive pigs had lower body weights, but the differences in body weights were non-significant ($P < 0.05$). This result is supported by several studies which showed little difference in growth between the two genotypes (Simpson and Webb, 1989; Sather et al., 1991; Pommier et al., 1992; Fewson et al., 1993 and Gueblez et al., 1995). Another report by Eikelenboom et al., 1978 suggested that gilts from Dutch Landrace and Dutch Yorkshire showed no difference in growth traits between halothane susceptible and resistant pigs.

When the rate of gain in weight was compared, the non-transported halothane negative group had the highest fortnightly rate of gain of 5.82 ± 0.86 followed by the transported halothane negative group with a rate of gain of 5.73 ± 0.71 kg. The least rate of gain was for non-transported halothane positive group, but the differences were not significant ($P<0.05$). Similar results were supported by Uremovic et al. (1993) who found that the growth rate of halothane resistant pigs was non-significantly superior to that of susceptible pigs.

Similarly, a greater body girth was observed for halothane negative animals (93.44 ± 1.56 Vs 91.42 ± 2 cm) but the difference was non-significant. Poltarsky and Bulla (1984) also observed higher daily gains in negative pigs. Likewise, Oster (1980) Wilde and De Wilde (1984), Jensen and Barton-Gade (1985), Janciene (1989), Timofeev et al. (1990), Babeev et al. (1991) and Babeev and Kazachok (1992) reported significantly higher average daily gain for halothane resistant pigs. This reduction in daily gain for positive pigs (Matthes et al., 1995) and their reduced growth rate was due to reduced appetite for halothane sensitive groups (McPhee et al., 1994).

The above results were entirely against the findings of Luescher et al. (1979) and Kadima et al. (1985) whose results showed that carriers grew faster than negative. Wittmann et al. (1993) also observed a higher daily gain for heterozygotes.

According to the present study transportation for five hours had no effect on piglet performance. This was supported by Sather et al. (1983) that transportation distance was not correlated with average daily gain. Though Rundgren (1988) found no interaction between the halothane genotype and transport at 25 kg on growth performance, transportation resulted in lower carcass lean contents at 100 kg.

While the results of this work suggest no significant effect of transportation for 150 km on piglet performance, Jeese et al. (1990) found that even transportation for 563 km did not affect the subsequent health or performance in fasted or nonfasted pigs. Rundgren et al. (1990b) also reported that daily gain was not significantly affected by transport.

5.3 Feed conversion efficiency

The halothane negative animals showed a trend of better feed conversion efficiency (3.78 ± 0.22) compared to the halothane positive pigs (4.15 ± 0.23). But the difference was non-significant. Similar reports were given by Webb and Jordan (1978), Timofeev and Luk-yanov (1990), Sather et al. (1991) and Fewson et al. (1993). But, Wilde and DeWilde (1984),and Babeev and Kazachok (1992) reported that the halothane negative pigs consumed less feed per kilogram gain and had better feed efficiency. In contrast to these results, Webb and Simpson (1986) obtained significantly better feed efficiency in halothane positive animals. Sensic (1989) and Leach et al. (1996) reported that halothane carrier (Nn) pigs had a better feed conversion efficiency than the other two genotypes.

The value of feed efficiency observed in the present study are similar to those reported from the same population earlier (Saseendran and Rajagopalan,1981). The better feed conversion efficiency of 3.38 ± 0.20 Vs 4.12 ± 1.45 of transported pigs in the present study indicated that transportation at 90 days of age had no effect on feed conversion efficiency. This was supported by Rundgren (1988), Rundgren et al. (1990b) and Jeese et al. (1990) where no difference in feed conversion efficiency were observed due to transportation.

5.4 Haematological changes

5.4.1 Blood pH

As no significant difference was noted for blood pH values, between halothane genotypes and between transported and non-transported animals, it can be concluded that the halothane gene and transportation had no effect on blood pH and blood bicarbonate and base level. The blood bicarbonate could buffer the pH value even after five hours of transport. However, the halothane negative animals showed a trend of higher blood pH values, indicating improvement in meat quality. Similar observations were cited by Boles et al. (1994), where increased blood pH and bicarbonate showed an improvement in meat quality.

5.4.2. Erythrocyte sedimentation rate

Erythrocyte sedimentation rate (ESR) was not affected between halothane genotypes. The mean ESR values for the non-transported halothane negative and positive animals were 17.18 ± 3.63 and 8.50 ± 1.72 mm per hr. Transportation resulted in an increase in ESR for both halothane genotypes. The transported halothane negative animals had an ESR of 22.67 ± 2.75 mm per hr and that of halothane positive group was 21.22 ± 3.14 mm per hr. There was significant ($P<0.05$) difference in ESR values of non-transported and transported halothane positive animals. When the hypothalamus-adenohypophysis and adrenal cortex were activated, a lowering of plasma iron and increase in ESR were observed by Cartwright et al. (1951) and Hamilton et al. (1950). Increased ESR in the present study might be due to this factor.

5.4.3. Packed cell volume (PCV)

In the present study, the PCV values between both halothane genotypes and between the transported and non-transported groups did not vary significantly. Swensen (1970) had reported that excitement increased the PCV and erythrocyte numbers due to release of catacholamines and the contraction of spleen mobilising erythrocytes in the circulatory system. In this experiment, the excitement due to transportation and mixing would have subsided by the end of five hours transport which resulted in normal PCV for the transported animals. Haemo-concentration as reported by Warriss and Brown (1983) would not have occurred.

5.4.4.1. Lactate dehydrogenase (LDH)

The mean serum lactate dehydrogenase values were higher for halothane positive animals than the halothane negative (127.23 IU per litre Vs 112.96 IU per litre). Thus it can be used in identifying stress sensitive pigs as reported earlier by Ludvigsen (1954). An apparently clear trend for higher values of LDH in positive animals tend to support earlier reports of Nikilchenko et al. (1986), Szilagyl et al. (1989) and Schaefer et al. (1990). But in the present study, the LDH values were not significantly different for the two genotypes. Conflicting reports on the accuracy of this enzyme in the prediction of stress susceptibility has been reported by Schmidt et al. (1973).

There was no significant difference in LDH values due to transportation. The mean values for transported and non-transported animals were 117.23 and 112.15 IU per litre. Contradicting to this Moss (1978) reported a significant progressive increase in serum enzyme activities when animals were taken from farm to slaughter house. Caola et al. (1978) found no clear difference in LDH values for pigs transported for different distances, but the LDH values were above normal for all transported groups.

--

5.4.4.2. Creatine phosphokinase (CPK)

The CPK values showed significant difference ($P<0.05$) between halothane positive and halothane negative animals. This was in accordance with the results of Ludvigsen (1954) who explained that muscle degeneration occurred more in stress susceptible pigs and as a result of it there will be high levels of this enzyme in the blood due to tissue damage. Higher plasma levels of CPK had been found in stress sensitive breeds of pigs, such as Pietrain and Poland China (Allen and Patterson, 1971, Reddy and Kastenschmidt, 1971).

Creatine kinase test can also be used as a selection criterion to estimate stress resistance and meat quality of transported pigs (Bickhardt et al., 1977). Pietrains showed higher creatine kinase activity than Yorkshire or Minnesota or their crosses after transportation stress. Janezic et al. (1988) and Bulla et al. (1988) noticed a significantly increased creatine kinase activity after stress in halothane sensitive animals. Szilagil et al. (1990) also reported increased CK activity after transport as seen in this study.

5.5 Carcass characteristics

5.5.1. Live weight of pigs at slaughter and shrinkage

The differences in live weight of pigs at slaughter between non-transported halothane negative and positive pigs were found to be non-significant ($P<0.05$). The similar live weight obtained for the experimental pigs might be due to the uniform growth rate observed in all the pigs irrespective of the treatment.

In an earlier study by Rundgren et al. (1990b) involving only one time transport at 90 days of age no difference in live weight at slaughter could be observed. Leach et al. (1996) had also reported similar slaughter weight between halothane genotypes. Whereas Kortz et al. (1995) reported a higher slaughter weight for pigs transported for more than 50 km over the ones subjected to transport of less than 25 km (84 kg Vs 74 kg). In the present study even after weaning and immediately before slaughter, no difference in body weight could be observed.

At 210 days of age the body weight attained by transported halothane negative and positive pigs were 65.5 ± 2.47 kg and 61.17 ± 3.24 kg respectively. The weight for non-transported pigs were 66.00 ± 2.12 kg and 58.67 ± 5.00 kg respectively. After the transport of 5 hr (150 km) halothane negative animals lost 5.1 ± 0.4 kg and halothane positive animals lost 3.417 ± 0.6 kg. The percentage of body weight loss were 7.206 ± 0.813 and 5.328 ± 0.824 for halothane negative and positive pigs respectively, but the difference was not significant (P<0.05). A lower shrinkage of 1.22 and 5.4 percent had been observed by Dantzer, 1970; Shutz, 1975 and Rundgren et al., (1990a) But a very high shrinkage of 32 per cent was observed by Chen et al. (1995).

In the present study it appeared that transportation at younger age of 90 days resulted in significantly higher shrinkage percentage in halothane resistant pigs than sensitive pigs (11.00 ± 0.503 Vs 6.847 ± 1.32).

5.5.2. Carcass length and dressing percentage

Halothane positive pigs and transported pigs had shorter carcass than the halothane negative and non-transported pigs. The shorter carcasses due to halothane genotype were observed by Sabec et al. (1987), Bergonzini et al. (1988) and Wittman et al. (1993). However the difference in carcass length between halothane genotypes were reported to be non-significant (Sabec et al., 1987; Leach et al., 1996). Whereas Rundgren (1990b) observed a significantly shorter carcasses in halothane positive pigs.

In both transported and non-transported pigs, halothane negative pigs had higher dressed weight than halothane positive pigs. In dressing percentage no trend towards any group could be observed. The result of the study was in confirmation with reports Sather et al. (1991c). Contradicting results were obtained by Rundgren (1988) with higher dressing percentage for reactors and by Leach et al. (1996) with a higher dressing percentage for heterozygotes. The dressing percentage of 77.44 obtained for transported animals were similar to that obtained for Kortz et al. (1995) when pigs were transported for more than 50 km.

5.5.3. Meat quality and meat pH

The average meat pH observed for halothane negative and positive pigs were 6.07 ± 0.15 and 5.69 ± 0.11 respectively. The difference was found to be highly significant ($P<0.01$). The lower pH observed for the positive pig in the present study was in agreement with the result obtained by Sencic et al. (1989), Holkova et al. (1992), Mlynek (1992) and Fewson et al. (1993). Eventhough there was no appreciable visual changes to the carcass indicating pale soft exudative (PSE) meat in any of the groups studied the lowered pH may be indicative of the reactors susceptibility for developing PSE meat. This was observed earlier by

Jensen and Barton-Gade (1985), Lundstrom et al. (1989), Casteel et al. (1995) and DeSmet et al. (1996).

The reactors appear to be vulnerable to stress as significantly lower pH ($P<0.01$) has been observed among pigs subjected to transport before slaughter.

Poor meat quality in halothane reactors had been observed by Simpson and Webb (1989), Sather et al. (1991b,c), Zhang et al. (1992), Jones et al. (1994), Leach et al. (1996). In the case of pigs subjected to transport lowest meat quality was observed among reactors (Rundgren, 1988). In contrast to this Chen et al. (1995) reported that meat quality was not influenced by transportation stress. Kortz et al. (1995) observed a superior meat quality among pigs transported for shorter distances than the pigs transported for longer distances.

5.5.4. Loin eye area

In the present study loin eye area was not affected due to halothane genotype. Loin eye area was higher in halothane positive pigs among non-transported group and lower in transported. Transported animals had a numerically lower loin eye area than the non-transported animals (27.98 cm^2 Vs 27.06 cm^2), but the difference was non-significant ($P<0.05$). When overall loin eye area of halothane positive and negative animals were compared there was no significant difference.

The non-significant difference of loin eye area between genotypes were observed by Leach et al. (1996). Significantly higher loin eye areas were observed in halothane positive pigs (Kralik et al, 1988;

Poltarsky, 1989, Schwerin and Kallweit, 1991, Holkova et al., 1992, Matthes and Schwerin, 1995). However, significantly lower loin eye area was observed by Babeev et al. (1992).

5.5.5. Backfat thickness

The lowest backfat thickness of 23.5 ± 0.18 mm was observed in non-transported halothane positive pigs and the highest of 29.1 ± 0.3 mm backfat thickness for transported halothane positive pigs. But no trend due to genotype and transport on backfat thickness could be observed. A higher backfat thickness of 29.1 and 32.6 mm in positive and negative animals respectively (Kralik et al., 1987) and 33.6 and 36.6 mm for positive and negative animals respectively (Bergonzini et al., 1988) were reported. Webb and Jordan (1978) reported a lower backfat thickness of 21 mm in positive pigs and 23.3 mm in negative pigs. However the backfat thickness between genotypes were not significantly different in the reports of Webb and Jordan (1978), Beckova and Holkova (1988), Holkova (1992) and Leach et al. (1996). In contrast to this Sabec et al. (1987) detected a significant increase in backfat thickness for halothane negative pigs.

5.5.6. Organ weights

Weights of heart, liver, kidney spleen, stomach and intestines were compared between the experimental group of pigs and could not observe any significant difference. This was not in agreement with the experiments where significantly lower organ weights were observed among halothane sensitive pigs by Nystrom and Anderson (1987), Rundgren et al. (1990b), Berg and Hausman (1991) and Nystrom and Anderson (1993).

5.5.7. Crude fat content of liver and kidney

The similar crude fat content of liver and kidney dry matter observed in the present study was in agreement with the study conducted by Rundgren (1988), Jones et al (1988), Rundgren et al. (1990b) except for the higher crude fat content of liver observed among transported group in his study.

SUMMARY

SUMMARY

An investigation was carried out in the University Pig Breeding Farm (UPBF), Mannuthy to assess the effect of transportation on the performance and carcass traits of halothane sensitive pigs.

Weaned piglets were randomly selected and screened for halothane sensitivity and put into four groups, (two halothane positive and two halothane negative) each comprising of six piglets. Two groups (one halothane positive and one halothane negative) were transported for a distance of 150 km for a duration of five hours. The behavioural characteristics, weight loss due to transport, growth performance and feed efficiency were studied.

At 210 days of age the transported groups were again subjected to 150 km of transport with an approximate duration of five hours and then all the animals were slaughtered. The carcass traits such as live weight at slaughter, shrinkage, carcass length, dressing percentage, loin eye area, backfat thickness and organ weights were studied. The meat quality was assessed by determining meat pH, and carcass was observed for pale soft exudative (PSE) meat. The crude fat content of liver and kidney was also determined.

To assess the haematological changes resulting from transportation, blood samples were collected after screening to halothane sensitive and resistant pigs, immediately after the two transportations and during the growing period at four months and six months of age. Blood samples were analysed for stress-related enzymes, lactate dehydrogenase and creatine phosphokinase. Other parameters observed were blood pH, erythrocyte sedimentation rate (ESR) and packed cell volume (PCV).

Neither the halothane genotype nor transportation influenced the growth performance, rate of gain and feed conversion efficiency by 210 days of age, the non-transported halothane negative and positive groups and transported halothane negative and positive groups had mean body weight of 66.00 $\pm$ 2.12 kg, 58.67$\pm$ 5.00 kg, 65.50 $\pm$ 2.75 kg and 61.17 $\pm$ 3.24 kg respectively.

There was not much difference in the behaviour between the positive and negative groups. However the positive groups showed better feeding temperament. Mixing during transportation resulted in fights between the genotypes, the halothane negative being more aggressive.

Shrinkage at 90 days of age showed significant difference ($P<0.01$) between the halothane genotypes. The halothane resistant pigs had higher loss in body weight than sensitive pigs, the percentage loss being 6.847 $\pm$ 1.32 and 11 $\pm$ 0.503 for halothane sensitive and resistant pigs respectively. At 210 days of age, the difference in loss in body weight between halothane genotypes was not significant ($P < 0.05$).

The carcass characteristics like live weight of pigs at slaughter, carcass length, dressing percentage, meat bone ratio, loin eye area, back fat thickness and organ weights did not differ between the genotypes or between the transported and non-transported groups.

There was significant difference ($P < 0.01$) in meat pH between the halothane genotypes and between transported and non-transported groups.

The mean pH values of meat of non-transported and transported groups were 6.10 $\pm$ 0.12 and 5.63 $\pm$ 1.70. The higher pH values observed in non-transported groups were indicative of better meat quality. The pH values of the two halothane genotypes were 6.07 $\pm$ 0.15 for negative group and 5.69 $\pm$ 0.11 for positive group. The difference between them being highly significant ($P < 0.01$).

When the haematological changes were assessed, the blood pH and PCV did not vary significantly between the two genotypes or between transported and non-transported group. The ESR of non-transported halothane positive pigs and transported halothane positive pigs varied significantly ($P < 0.05$). There was a rise in ESR as a result of transportation stress.

The stress related enzymes, lactate dehydrogenase (LDH) and creatine phosphokinase increased due to transportation. The LDH values were non-significantly higher for transported pigs. The CPK values varied significantly ($P < 0.05$) between the genotypes. The halothane positive animals had higher values. The CPK values were also significantly higher for transported group ($P < 0.05$).

The study showed that there was no long term effect of stress due to transportation, which affected the growth performance. Transportation immediately before slaughter resulted in a lowered meat pH which had an adverse effect on meat quality. The results of the present study indicate that creatine phosphokinase level in blood serum can be used as an efficient tool in determining stress susceptible pigs.

REFERENCES

References

Aalhus, J.L., Jones, S.D.M., Robertson, W.M., Tong, A.K.W. and Sather, A.P. (1991). Growth characteristics and carcass composition of pigs with known genotypes for stress susceptibility over a weight range of 70 to 120 kg. Anim. Prod., 52: 347.

Allen, W.M. and Patterson, D.S.P.(1971). The possible relationship between plasma creatine phosphokinase activity and muscle characteristics in the pig. Proc. 2nd int. Symp. Condition Meat Quality of pigs, Zeist, pp. 90-96 Pudoc, Wageningen.

A.O.A.C. (1984). OFFICIAL METHODS OF ANALYSIS (15th ed.). Association of Agricultural Chemists, Washington, D.C.

Babeev, A.A., Kazachok, G.E., Efimov, V.I. (1991). Productivity of pigs in relation to stress resistance. Zootekhniya No.11, 27-30.

Babeev, A.A., Kazachok, G.E. (1992). A study of stress reactions and creation of a resistant herd of pig. Vest. sel. Khoz. Nauka, Mosk. 4 : 102-108.

Beckova, R.; Holkova, I. (1988). The effect of genotype at the halothane locus on the reproductive performance and carcass quality of pigs. Zivocisna. Vyroba.33 : 681-690

Berg, R. and Hausmann, D. (1991). The importance of absolute and relative heart weight for stress induced cardiomyopathy (PSS) in pigs. Anim. Brced Abstr. 60 : 5163

Bergmeyer, H.W. (1965). METHODS OF ENZYMATIC ANALYSIS. ed. 2. Valog Clinic.

Bergonzini, E., Fabbri, R., Rosi, M.A., Masoero, G. (1988). Blood creatinine, finishing and carcass performance and cured hams of halothane positive and negative pigs. Rivista disuinicoltura 29 : 33-37

Bickhardt, K., Flock, D.K., Richter, L. (1977). Creatine kinase test (CK test) as a selection criteriion to estimate stress resistance and meat quality in pigs. Vet. Sci. Commu. 1: 225-233.

Boles, J.A., Patience, J.F.,Shaefer, A.L., Aalhus, J.L. (1994). Effect of oral loading of acid or base on the incidence of pale soft excudative pork (PSE)in stress-susceptible pigs. Meat. Sci. 37 : 181-194

Bulla, J., Bullova, M., Kolataj. A. (1991) Some ethological and physiological indicators of MHS in pigs. J. Anim.Breed.Genet. 108. 315-318.

Caola, G.; Ferlazzo, A.; Omero, A. (1978). Serum lactate dehydrogenase in swine after brief transportation. Archo. Vet. Ital. 29 : 152-155.

Carden, A.E. and Webb, A.J. (1984). The effect of age on halothane susceptibility in pigs. Anim prod. 38 : 469-475

Cartwright, G.E., Hamilton, L.D., Gubler, C.J., Fellows, N.M. Ashenbrucker, H. and Wintrobe, M.M. (1951). The anemia of infection XIII : Studies on experimentally produced acute hypoferremia in dogs and the relationship of the adrenal cortex to hypoferremia. J. Clin. Invest, 30 : 161-174

Casteels, M., Van Oeckel, M.J., Boschaerts, L., Spincemaille, G and Boucque, C.V. (1995). The relationship between carcass, meat and eating quality if three pig genotypes Meat Sci. 40 : 253

Chang, H.L., Wu, S.C., Wu. M.C. (1994). Initiation of rigid limbs in halothane tests of Landrace, Yorkshire and Duroc pigs. Journal of Chinese Society of Animal Science. J. Chin. Soc. Anim. Sci. 23 : 235-245.

Chen, C.M., Fang, H.C., Yun, W.S., Suwjuane, H., Lee, S.W. and Liehchin, L. (1995). Effects of transportation conditions on live weight loss and carcass quality of pigs. J. Chin. Soc. Anim. Sci. 24 : 329-344

Coffin, D.L. 1953. MANUAL OF VETERINARY CLINICAL PATHOLOGY 3rd ed. Cornell U. Press, Ithaca, N.Y.

Culau, P.V. , Ourique, J.R., Nicolaicwski, S. (1993). Effects of Preslaughter management on the incidence of PSE and DFD in pigs. Latinoamericanos de produccion Animal 1 : 139-146

Dantzer, R., (1970). Etude des pertes de poids subies par des porcelets au cours de transports. Ann. Rech. Vet. 1 : 179-187

Davies, W. (1994). The porcine stress syndrome. Anim. Biotechnol. 5 : 169-172

DeSmet, S.M., Pauwels, H., De Bie, S., Demeyer, D. I., Callowier, J., Eeckhout, W. (1996). Effect of Halothane genotype, Breed, Feed Withdrawal and Lairage on pork Quality of Belgian Slaughter pigs. J. Anim. Sci. 74 : 1854-1863

Eikelenboom, G., Minkema, D., van Eldik, P. and Sybesma, W., 1978. Production characteristics of Dutch Yorkshire pigs as related to their suscephibility for the halothane induced malignant hyperthermia syndrome. Livest. Prod. Sci., 5: 277-284.

Ekkel, E.D., Savenije, B., Schouten, W.G.P., Tielen, M.J.M. (1996) Health, Welfare and productivity of pigs housed under specific-stress-free conditions in comparison with two-site systems. J. Anim. Sci. 74: 2081-2087.

Eldik, P. van., Van, E.P. (1975). Relationship between halothane susceptibility and production characters in pigs, depending on the level of feeding. Report N. C-265.

Fahraeus, R. 1929. The suspension stability of the blood. Physiol. Rev. 9: 241-71.

Fewson, D., Rathfeldor, A., Muller, E. (1993). Investigations on the correltions between the percentage of carcass lean, meat quality and stress resistance in pigs of different genetic origin 1. Importance of morphology of the eye-muscle. Anim. Breed. Abstr. 62(4): 2038.

Folch, J., Lees, M. and Stanley, G.H.S. (1956). A simple method for the isolation and purification of total lipids from animal time. J. Biol. Chem. 226: 497-509.

Fraser, A.F., Brom, D.M. (1990) FARM ANIMAL BEHAVIOUR AND WELFARE 3rd ed. English Language Book Society/Bailliere Tindall. pp. 359-369.

Geers, R., Bleus, E., Schie, T. van, Ville, H., Gerald, H., Janssens, S., Nackaerts, G, Ducuypere, E., Jourquin, J. (1994). Transport of pigs different with respect to the halothane gene: stress assessment. J. Anim. Sci. 72: 2552-58.

Goossens, P. (1973). Tierarztliche Hochschule, Hannover, pp. 58.

Grandin, T. (1980) The effect of stress on livestock and meat quality prior to and during slaughter. International Journal for the study of Animal problems. 1: 313-337.

Gueblez, R., Pahoeuf, F., Sellier, P., Bouffand, M., boulard, J., Brault, D. and Tiran, M.H. le. (1995). Effect of halothane genotype on finishing performance, carcasses and meat quality of pigs. Anim. Breed. Abstr. 64(9): 5436.

Guizzardi, F., Calcinardi, C. (1980) Mortality of swine during and after transport (in Italy). Archo. vet. ital. 31.11.95.

Hall, L.W. (1971) WRIGHT'S VETERINARY ANAESTHESIA AND ANALGESIA 7th ed. Billiere Tindall, London. pp. 220, 353.

Hamilton, L.D., Gubler, C.J., Cartwaright, G.E., and Wintrobe, M.M (1950). Divisional variation in the plasma iron level in man. Proc. Soc. Exp. Biol. Med. 75: 65-68.

Holkova, I., Kovaricek, J., Beckova, R. (1992). The performance of pigs of different genotypes in relation to the halothane locus. Zivocisna Vyroba 37: 1003-1008.

Hovenier, R., Kanis, E., Asseldonk, T. van, Westerin, N.G. (1993) Breeding for pig meat quality in halothane negative population-a review. Pig News Inf. 14: 17-25.

Janciene, I (1989) The relationship of stress susceptibility of pigs of different genotypes with growth and carcass traits. Anim Breed. Abstr. 60: 4471.

Jeese, G.W., Weiss, C.N.; Mayes, H.F., Zinn, G.M. (1990) Effect of marketing treatments and transportation on feeder pig performance. J. Anim. Sci. 68: 611-617.

Jensen, P., and Barton Gade, P.A. (1985) Performance and carcass characteristics of pigs with known halothane genotypes for halothane susceptibility and meat quality in pigs. Pso EAAP publ. no: 23.

Jesse, G.W., Weiss, C.N., Mayes, H.F; Zinn, G.M. (1990) Effect of marketing treatments and transportation on feeder pig performance. J. Anim. Sci. 68: 611-617.

Jones, S.D.M., Murray, A.C., Sather, A.P. and Rebertson, W.M. (1988) Body pioporhin and carcass comparifun of pigs with known genotypes for stress pigs with known genotypes for stress susceptibility fasted for different periods of time prior to slaughter. Can. J. Anim. Sci. 68 : 139-149.

Kadima, N. M., Bogner, H., Krausslich, H., Schmid, D.O. Sprengel, D., Matzke, P., Blendl, H.M.,Gehra, H. (1985). Relationships among blood group markers, stress resistance, fattening performance and carcass characters and quality of German Landrace pigs. Bayerisches Landwirtschaftliches Jahrbuch. 62 : 601-629.

Klont, R.E., Lambooy, E., Loglestyn, J.G. (1993). Effect of preslaughter anaesthesia on muscle metabolism and meat quality of pigs of different halothane genotypes. J. Anim. Sci. 71: 1477-85.

Kortz, J., Karamucki, T., Kubasik, W., Natalezyk Szymkowska, W. (1992). The effect of transport of animals on carcass and meat quality of pigs slaughtered at different intervals after transport. Anim. Breed. Abstr. 61 1847.

Kortz, J., Gardzielewska, J., Karamucki, T., Jakerbowska, M., Wojdak, L. (1995a) The effect of preslaughter transportation distance, carcass weight, and backfat thickness on the frequencies of normal PSE and DFD meat. Zootechnika 32: 101-107.

Kortz, J., Karamucki, T., Gardzielewska, J., Szafran, E. (1995b). Characteristics of porkers bred on private farms and on meat industry-owned farms in relation to different distances of transportation to the slaughter house. Adv. Agric. Sciences. 4: 55-61.

Kralik, G., Sencic, D., Petricevic, A., Komendanovic, V., Maltar, Z. (1988) A comparison of the performance of halothane positive and halothane negative finished pig. Zbornik Radova 16: 125-132.

Krider, J.L. and Carroll, W.E. (1971) SWINE PRODUCTION (4th ed) Tata Mc Graw-Hill Publishing Company Ltd. pp: 63-70.

Leach, L.M., Ellis, M., Sutton, D.S., Mckieth, F.k., Wilson, E.R. (1996). The growth performance, carcass characteristics and meat quality of halothane carrier and negative pigs. J. Anim. Sci. 74: 934-943.

Lister, D. (1970) In PHYSIOLOGY AND BIOCHEMISTRY OF MUSCLE AS A FOOD. Briskey, E.G., Cassens, R.G. and Marsh, R.B.(Eds). Vol 2. p. 705. University Wisconsin Press, Madison.

Lundstrom, K., Essen-Gustavsson, B., Rundgren, M., Edfors Lilja, I., Malmfors, G. (1989) Effect of halothane genotype on muscle metabolism at slaughter and its relationship with meat quality: A within-litter comparison Meat Sci. 25: 251.

Mabry, J.W. (1977). Porcine stress syndrome : inheritance prediction and performance characteristics. Diss. Abstr. Int. 38 : 2956.

Matthes, W., Schwerin, M. (1995) Use of the malignant hyperthermia syndrome (MHS) gene test for the determination of stress susceptibility. Neue Landwirtchaft (6): 56-58.

McPhee, C.P, Daniels, L.J, Kramer, H.L, Macbeth, G. M., Noble, J.W. (1994). The effects of selection for lean growth and the halothane allele on growth performance and mortality of pigs in the tropical environment. Livest. Prod. Sci. 38: 117-123.

McPhee, C.P. and Trout, G.R. (1995) The effects of selection for lean growth and the halothane allele on carcass and meat quality of pigs transported long and short distances to slaughter. Livest. Prod. Sci. 42: 55-62.

Meese, G.B. and Ewbank, R. (1973). The establishment and nature of the dominance hierarchy in the domesticated pig. Anim. Behav., 21: 326-334.

Mitchell, G. and Heffron, J.J.A. (1982). Porcine stress syndromes. Adv. Food Res. 28: 167-230.

Mlynek, J. (1992) An evaluation of performance and quality traits of pigs responding positively and negatively to halothane. Zootechnicka Rada 9: 169-170.

Murray, A.C. and Jones, S.D.M. (1992) The effect of mixing, fasting and genotype on carcass shrinkage and pork quality Proceedings 38th International Congress of Meat Science and Technology. 2.

Murray, A.C. and Jones, S.D.M. (1994) The effect of mixing, feed restriction and genotype with respect to stress susceptibility on pork carcass and meat quality. Can. J. Anim. Sci. 74: 587-594.

Nikitchenko, I.N., Gorin, V.V. and Yakushik, V.N., (1986). Use of halothane test in the selection of pigs. Anim. Breed. Abstr. 57(3): 1812.

Nystrom, P.E., and Anderson, K. (1987) Halotangenens inverkan pa svin produktionen Swedish Univ. Agric. Sci., The extension service, S-75007 Uppsala, Report No. 109, pp 81-89.

Nystrom, P.E. and Anderson, K. (1993) Halothane gene effects on reproduction, production and organ weights in pigs. Acta. Vet. Scand 43: 201-206.

Oster, W. (1980). Halothane test in relation to breed and carcass characters. Landesanstalt fur Schweinezucht Forchheim Research and Progress report. 81-83.

Pearson, A.J. and Kilgour, R. (1980). The transport of stock-on assessment of its effects. In: M. Wodzicka-Tomaszewska, T.N. Edey and J.J. Lynch (Eds.) BEHAVIOUR ION RELATION TO REPRODUCTION, MANAGEMENT AND HEALTH OF FARM ANIMALS. Reviews in Rural Science, No, IV.

Podogaev, V.A. (1989). The performance and meat traits in pigs of different stress susceptibility Zootekhniya 9: 25-27.

Poltarsky, J. (1989). Carcass and meat quality of pigs suffering from the malignant hyperthermia syndrome Zivocisna Vyroba. 34: 807-814.

Poltarsky, J., Bulla, J. (1984) The performance, finishing ability and carcass quality of pigs responding differently to halothane anaesthesia. Pol nohospodarstvo 30: 221-227.

Poltarsky, J., Bulla, J. (1984) Halothane anaesthesia as a test of susceptibility to stress, constitution and poor quality of meat in pigs. Zivocisna Vyroba. 29: 703-802.

Pommier, S.A., Houde, A., Rousseau, F. and Savoie, Y. (1992). The effect of malignant hyperthermia genotype as determined by a restriction endonuclease assay on carcass characteristic of commercial cross breed pigs. Can. J. Anim. Sci. 72: 973-976.

Provaznik, L. and Valenta, J. (1994). The effect of transport and resting time of pigs before slaughter on meat quality. Zivocisna Vyroba 39: 1063-1072.

Rundgren, M. (1988). Growing pig performance: effects of dietary fibre, the halothane gene, transportation and mixing Rapport-Institutionen-for-Husdjurens-Utfodring-och-vard. 172: 124pp.

Rundgren, M., Lundstrom, K., Edfors-Lilja, I.; Juneja, R.K. (1990a)A within litter comparison of the three halothane genotypes. I. Piglet performance and effects of transportation and amperozide treatment at 2 weeks of age. Livest. Prod. Sci. 26: 137-153.

Rundgren, M., Lundstrom, K., Edfors-Lilja, I. (1990b) A within litter comparison of the three halothane genotypes. 2. Performance, carcass quality, organ development and long term effects of transportation and amperozide treatment. Livest. Prod. Sci. 26: 231-243.

Sabec, D., Lazar, P., Pokorn, A., Janezic, M., Cerne, I., Pirc, B. (1987). Fattening and carcass characteristics of pig succeptible or resistant to halothane. Zbornik Biotehniske Fakultete Univerze Edvarda Kardelja v. Lyubljani Veterinarstvo 24: 63-68.

Saseendran, P.C. and Rajagopalan, T.G. (1981) Note on the efficiency and economics of rearing of indigenous and exotic pigs Indian J. Anim. Sci. 51: 1003-1004.

Sather, A.P., Murray, A.C., Zawadski, S.M., Johnson, P. (1991a) The effect of halothane gene on pork production and meat quality of pigs reared under commercial conditions. Can. J. Anim. Sci. 71: 959-967.

Sather, A.P., Jones, S.D.M., and Tong, A.K.W. (1991 b) Halothane genotype by weight interactions on pig meat quality. Can. J. Anim. Sci. 71: 645.

Sather, A.P., Murray, A.C., Zawadski, S.M., and Johnson, P. (1991 c) The effect of the halothane gene on pork production and meat quality of pigs reared under commercial conditions. Can. J. Anim. Sci. 71: 959.

Sather, A.P., Jones, S.D.M., Squires, Tong, A.K.W., Zawadski, S. (1995) Antemortem handling effects on the behaviour, carcass yield and meat quality of market weight entire male pigs. Can. J. Anim. Sci. 75: 45-56.

Schaefer, A.L., Sather, A.P., Tong, A.K.W., Lepagi, P. (1989). Behaviour in pigs from three genotypes segregating at the halothane locus. Appl. Anim. Behav. Sci. 23: 15-25.

Schaefer, A.L., Doornenbal, H., Sather, A.P., Tong. A.K.W., Jones, S.D.M and Murray, A.C. (1990). The use of blood serum components in the identification of stress susceptible and carrier pigs. Can. J. Anim. Sci. 70(3): 845-855.

Schmidt-Nielsen, K. (1990) ANIMAL PHYSIOLOGY, ADAPTATION AND ENVIRONMENT (4th ed) Cambridge University Press, pp. 87-88.

Schutz, H. (1975) The influence of feeding time before transportation on the heart rate, body temperature and congestion of the ear arteries during and after transport of pigs. Tierarztliche Hochschule, Hannover, p. 51.

Searey, R.L. (1969).DIAGNOSTIC BIOCHEMISTRY. McGrane Hill, New York NT.

Sellier, P., Manin, G., Talmant, A., Jacquet, B. and Runavot, J.P. (1988) Influence of halothane susceptibility and of final pH on the quality of meat from pigs of 3 breed. Anim. Breed. Abstr. 57 (12): 7939.

Sencic, D., Petricevic, A., Kralik, G. (1989) Stress in pigs and Meat quality. Stocarstvo 43: 259-268.

Shaefer A.L., Sather, A.P., Tong, A.K.W., Lepagi. (1989). Behaviour in pigs from three genotypes segregating at the halothane locus. Appl. Anim. Behav. Sci. 23: 15-25.

Simpson, S.P. and Webb, A.J. (1989). Growth and carcass performance of British Landrace pigs heterozygous at the halothane locus. Anim. Prod. 49: 503-509.

Snedecor, G.W. and Cochran, W.G. (1967). STATISTICAL METHODS. (6th ed). The IOWA State University Press, Amer, USA.

Strehler, L. and McElroy, W.D. (1957) In: METHODS IN ENZYMOLOGY by Colowick, S.P. and Kaplan, N. O. (Ed) Vol. III, Academic Press INC; Publishers, New York.

Sybesma, W. and Eikelenboom, G. (1969) Malignant hyperthemia syndrome in pigs. Neth. J. Vet. Sci. 2: 155-160.

Swenson, M.J. (1970). Physiological properties, cellular and chemical constituents of blood. In. Swenson, M.J. (Ed): DUKES PHYSIOLOGY OF DOMESTIC ANIMALS (8th ed) Comstock Publishing Associates, Cornell University Press.

Szilagyl, M., Laky, G., Suri, A. and Guba, F (1989) Activities of some serum enzymes in halothane reacted and non-reacted pigs. Acta. Vet. Hung. 37(1-2): 117-121.

Timofeev, L.V. and Luk'yanov, V.N. (1990) The performance, meat quality and behaviour of pigs with different types of stress resistance. Anim. Breed. Abstr. 60 (7) 6644.

Uremovic, M., Uremovic, Z, Basic, I. (1993) Carcass production and quality in relation to the porcine stress syndrome. Poljopr. znanst. Smotra. 58: 395-404.

Valenta, J. and Provaznik, J. (1995) Determination of PSE defects in pigmeat using electric conductivity in slaughtered pigs with respect to the duration of transportation and resting time before the slaughter. Zivocisna-Vyroba 40: 513-518.

Van Putton, G. and Elshof, W.J. (1978) Observation on the effect of transport on the well being and lean quality of slaughter pigs Anim. Regul. Stud., 1: 247-271.

Warnants, N., Eeckhout, W. and Boucque, C. V. (1993) Serum pyruvate kinase and its relation to stress susceptibility in pigs. J. Anim. Breed. Genet. 110: 357-362.

Warris, P.D. and Brown S.N. (1983) The influence of preslaughter fasting on carcass and liver yield in pigs. Livest. Prod. Sci. 10: 273.

Webb, A.J. (1995) Further challenges in pig genetics. Anim. Breed. Abstr. 63: 731.

Webb, A.J. and Jordan, C.H.C (1978) Halothane sensitivity as a field test for stress susceptibility in the pigs. Anim. Prod. 26: 157-68.

Webb. A.J., Carden, A.E., Smith, C. and Imlah, P., (1982) Porcine stress syndrome in pig breeding. 2nd World Congress on Genetics Applied to Livestock Production. V. Madrid. pp. 588-608.

Webb, A.J., Simpson, S.P. (1986) Performance of British Landrace pigs selected for high and low incidence of Halothane sensitivity Anim. Prod. 43: 493-503.

Wenzlawowicz, M. von., Holleben, K. von., Mickwitz, G. Von. (1996). Meat quality in pigs. Investigations regarding stress, carcass weight and percentage of lean meat. Anim. Breed. Abstr. 64: 4345.

Wittmann, W., Peschke, W., Littmann, E. Behringer, J., Birkenmaier, S., Dovc. P., Forster, M. (1993). Finishing and carcass traits of German Landrace barrows in relation to MHS genotype zuchtungskunde 65: 197-205.

Wilde, R.O. de., De, Wilde, R.O. (1984) Comparison of halothane-sensitive and halothane resistant litter-mate pigs for growth, carcass composition, hormonal status and energy balance. Livest. Prod. Sci. 11: 303-313.

Wintrobe, M.M. (1929) A simple and accurate hemotocrit. J. Lab. Clin. Med.

Wintrobe, M.M. and Landsberg J.W. (1935). A standardized technique for the blood sedimentation test. Am. J. Med. Sci. 189: 102.

Wolf-Schwerin, C. and Kallweit, E. (1991). Stress reaction and performance traits of defined genotypes of German Landrace. Anim. Breed. Abstr. 59(5): 3450.

Wood-Gush, D.G.M., Jensen, P., Algers, B. (1990). Behaviour of pigs in a novel semi-natural environment. Biology Behav. 15: 62-73.

Zhang, W., Kuhlers, Z.L., Rempel, W. E. (1992). Halothane gene and swine performance. J. Anim. Sci. 70: 1307-1313.

EFFECT OF TRANSPORTATION ON THE PERFORMANCE AND CARCASS TRAITS OF HALOTHANE SENSITIVE PIGS

By
MANJU SASIDHARAN

ABSTRACT OF A THESIS
submitted in partial fulfilment of the
requirement for the degree of

MASTER OF VETERINARY SCIENCE
Faculty of Veterinary and Animal Sciences
Kerala Agricultrual University

Department of Livestock Production Management
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy, Thrissur

1997

Abstract

A study to assess the effect of transportation on the performance and carcass traits of halothane sensitive pigs was carried out. Twenty four weaner piglets were selected after screening for halothane sensitivity. Twelve piglets, six from halothane positive and six from halothane negative were transported. The halothane negative pigs showed more aggressive behaviour during transport, and the loss in body weight was significantly ($P < 0.01$) higher for the halothane negative pigs. A transportation for 150 km (Five hours) did not affect the further growth performance, average fortnightly gain and feed conversion efficiency.

At 210 days of age the transported group was subjected to a second transportation of 150 km and were slaughtered and carcass characteristic were studied. Shrinkage was more for halothane negative group.

The live weight at slaughter, carcass length dressing percentage, loin eye area, backfat thickness and organ weights did not show any significant difference. The meat pH was lower for halothane positive pigs and transported group indicative of pale soft exudative (PSE) condition. The crude fat content of liver and kidney did not differ between any of the groups.

Packed cell volume and blood pH did not vary between the groups. Erythrocyte sedimentation rate was significantly ($P < 0.05$) higher for transported halothane positive group. There was no significant difference in serum lactate dehydrogenase content. But serum creatine phosphokinase was higher for halothane positive pigs and the values increased on transportation.