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THE INFLUENCE OF BREED, CASTRATION AND AGE ON MUSCLE FIBRE TYPE AND DIAMETER IN FRIESLAND AND AFRIKANER CATTLE

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OPSOMMING: DIE INVLOED VAN RAS, GESLAG EN OUDERDOM OP DIE TIPE EN DEURSNEË VAN SPIERVESELS VAN FRIES- EN AFRIKANERBEESTE.

Bulle en osse van die Afrikaner- en Friesrasse op *ad lib.* voeding is op verskillende ouderdomme van geboorte tot en met 24 maande geslag. Monsters van die *M. semimembranosus* en *M. semitendinosus* (ligte en donker deel) is histochemies ondersoek met barnsteendehidrogenase vir rooi en wit spiervesels en die spierveseldeursnee is ook gemeet. Geen groepering van die spierveseltipes in patrone kon waargeneem word nie. 'n Geleidelike verskuiwing van rooi- na witspiervesels vind met toenemende ouderdom plaas. Die Fries het 'n groter persentasie wit spiervesels en 'n laer persentasie rooi spiervesels as die Afrikaner vir die betrokke spiere. Bulle het 'n groter persentasie rooispiervesels en 'n laer persentasie witspiervesels as die osse. Die toename in spierveseldeursnee volg 'n kenmerkende patroon vir die betrokke spiere. Die *M. semimembranosus* en *M. semitendinosus* (donker deel) toon 'n toename tot op 12 maande voordat spierveseldeursnee afplat terwyl die *M. semitendinosus* (ligte deel) 'n toename tot 20 maande toon voor afplatting plaasvind. Wit spiervesels het 'n groter spierveseldeursnee as rooi spiervesels by alle ouderdomme. Die Afrikanerbulle het 'n kleiner gemiddelde spierveseldeursnee as die Friesbulle. Die bulle egter, het 'n groter gemiddelde spierveseldeursnee as die osse ten spyte van die laer persentasie wit spiervesels. Die moontlike verwantskap tussen die tipe spiermetabolisme en vleiskwaliteitseienskappe word bespreek.

SUMMARY:

Bulls and steers from Afrikaner and Friesland cattle fed *ad lib.* were slaughtered at different ages from birth to 24 months inclusive. Samples were taken from the *M. semimembranosus* and *M. semitendinosus* (dark and light) and histochemically treated with succinic dehydrogenase for red and white muscle fibre identification. Muscle fibre diameter was also determined. No grouping into any particular pattern of the muscle fibre types could be observed. A gradual transition from red to white muscle fibre types occurs with age. The Friesland has a larger percentage white muscle fibres and a lower percentage red muscle fibres than the Afrikaner for the muscles concerned. Bulls have a larger percentage red muscle fibres and a lower percentage white muscle fibres than the steers. The increase in muscle fibre diameter follows a characteristic pattern for the particular muscles. The *M. semimembranosus* and the *M. semitendinosus* (dark area) show an increase in diameter up to 12 months before tapering off while the *M. semitendinosus* (light area) shows an increase up to 20 months before levelling off. White muscle fibre diameter is larger than red muscle fibre diameter at all ages. The Afrikaner bulls have a smaller mean fibre diameter than Friesland bulls. The bulls, however, have a larger mean muscle fibre diameter than the steers notwithstanding the lower percentage of white muscle fibres. The possible relationship between the type of muscle metabolism and meat quality characteristics is discussed.

The recognized fibre types found in skeletal muscle have been identified by employing specific controlled histochemical procedures such as succinic dehydrogenase, phosphorylase, myosin adenosine triphosphatase. No doubt with further advancement in histochemical techniques more subtle differences between muscle fibres could be demonstrated in future. For the present only 3 types are acknowledged – the white, red and intermediate muscle fibres. Ashmore & Addis (1972) recognised 2 types of red fibres, α-red and β-red as demonstrated by myosin ATP-ase. Of the 2 types the α-red fibres go through an intermediary stage to white fibres while β-red fibres remain as such throughout life. Possibly the intermediate muscle fibre type is a true intermediary, representing a transitional stage between the α-red and the white fibres (Ashmore & Addis, 1972).

A detailed description of these particular fibre types have been given for a variety of animal species from invertebrates (Ogata & Mori, 1964) to humans (Dubowitz & Pearse, 1960). The effect of double muscling on fibre types have been discussed by West (1974) who found the homozygous double muscled animal to have more and larger white fibres than normal animals.

The importance of knowing the fibre type composition of the muscle before interpreting results from biochemical and physiological research in relation to meat science is emphasized by Moddy & Cassens (1968). The influence of sex, breed, nutrition, environment and stress on muscle fibre type in terms of the post mortem muscles is also accentuated. Hunt & Hedrick (1977) studied the histochemical and histological structure of muscles of beef carcasses selected from 4 different quality groups to illustrate differences in their metabolic potential.

To our knowledge no comparison has been made, as yet, of the muscle fibre type content of muscles of different strains of cattle. In the Republic of South Africa the beef cattle breed which outnumbers all others is the Afrikaner as it lends itself extremely well to prevailing extensive ranching conditions. It is, however, a type inclined to deposit fat early during the finishing period. The Friesland is numerically the most important dairy breed in the country, and is a type associated with the production of lean meat presently preferred by the consumer.

For this reason these breeds were chosen for a detailed study of certain major aspects of meat characteristics which will be published elsewhere (Boccard, Naudé, Cronjé, Smit, Venter & Rossouw, 1977). Some of the available material was used for studying the muscle fibre type percentage and diameter in selected age groups. The *M. semimembranosus* and *M. semitendinosus* were chosen for this study in view of their economic importance in the beef animal as well as their inherent metabolic differences peculiar to every muscle.

Procedure

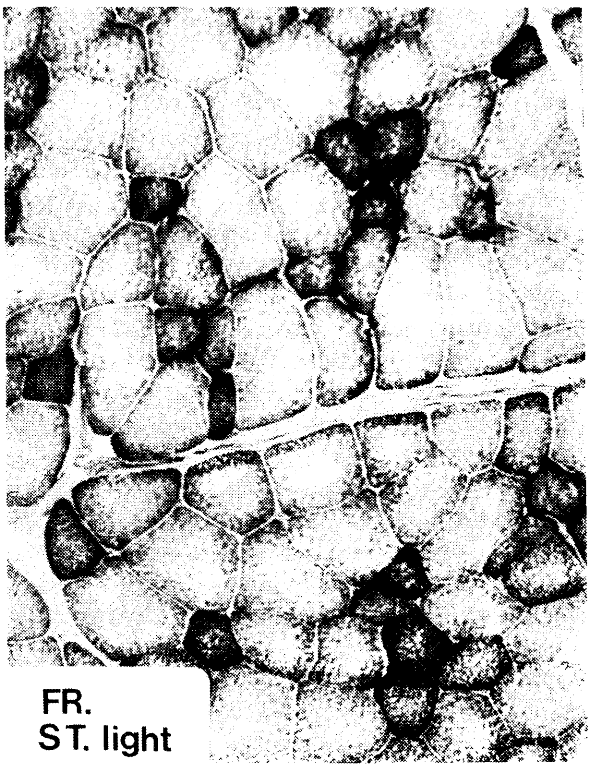
Afrikaner and Friesland bull calves and bulls from age one week to 24 months as well as steers from age 12 months were used. The steers were castrated at 8 months of age. Of both breeds 5 bulls and 5 castrates were slaughtered at 12, 16, 20 and 24 months respectively, as well as 5 bull calves at one week and again at 8 months of age.

All animals were stunned by captive bolt and the blood vessels severed. Immediately after skinning, sections of the *M. semitendinosus* and *M. semimenbranosus* were rapidly removed from the carcass. A thick portion sometimes known as a "steak" was removed from the central portion of each muscle. From these chunks of muscle pencil sized strips, approximately 5 x 7 mm were quickly excised with a dissecting blade from both the light and dark side of the *M. semitendinosus*. These strips were fastened at rest length by tying the ends with sewing cotton (no. 40) to small screws fitted on a wooden block of approximately 120 x 20 x 5 mm. This prevented a rapid contraction of the muscle with a sudden immersion in liquid nitrogen. Exposure to the nitrogen was about 20 seconds and after removal from the blocks the frozen strips were transported in a Dewar flask on dry ice to the laboratory for processing. Conditioning of the samples was done in an ordinary deep freeze at approximately minus 25°C before sectioning on a cryostat.

For histochemical demonstration of succinic dehydrogenase situated in the mitochondria the nitro-blue tetrazolium technique of Malaty & Bourne (1953) was used. Fibres were classified into red, white and intermediate according to the intensity of the staining reaction, and all future reference to fibre types will be to the SDH-types. Fibre diameter was taken as the mean of the long axis and the longest short axis (Dreyer, Naudé & Gouws, 1972). All measurements and counts were executed on a Reichert Visopan at magnification 500x. Fifty measurements were taken and the fibres identified simultaneously. In this way the diameter of each fibre type could also be determined separately.

Plate 1

Cross sections of M. semitendinosus *(ST) (light) of the Afrikaner (AFR) and Friesland (FR) steers showing the lack of pattern formation. Note the larger number of red fibres in the Afrikaner steer muscle (x 144)*



Data was statistically analysed using a 3 way analysis of variance (Snedecor & Cochrane, 1966).

Results and Discussion

The muscle sections of the *M. semitendinosus* dark and light and the *M. semimembranosus* reacted for succinic dehydrogenase, were scanned microscopically for a possible pattern formation of the muscle fibre types. In pig muscle the pattern is characteristic – a few red fibres are loated centrally in a muscle bundle surrounded by white fibres very much larger in size (Morita, Cassens & Briskey, 1969). This fits in with the theory of Ashmore & Addis (1972) that the β-red serves as a nucleus around which the other fibre types develop. The beef muscle shows no comparable grouping, but tends to follow the pattern as described by James (1971) for the rabbit muscle. According to him the appearance of any pattern depends on the ratio of red to white muscle fibres. However, in general there is a tendency for the white mûscle fibres to be located peripherally in a bundle and for the red muscle fibres to be more centrally situated. In the beef animal the muscle fibres tend to follow a similar pattern (Plate 1).

As the formazan is deposited in the mitochondria it is clear that the highest density of mitochondria occurs in the smaller fibres and as fibre size increases, mitochondrial density decreases. When frozen sections are incubated with succinate in the presence of nitro-blue tetrazolium in a buffered medium the enzyme activity will produce a disposition of formazan pigment (Barka, 1963). The 3 fibre types were readily discernable on this basis and the percentage and diameters of each were determined.

PERCENTAGE OF MUSCLE FIBRE TYPES

Percentage of red muscle fibres of bulls

i) *Age*

When muscle fibre types are considered collectively for all age groups highly significant changes are indicated for changes in percentage with an increase in chronological age. The percentage of red fibres in the *M. semimembranosus* shows a decline with an increase in age especially between birth and 12 (Afrikaner) to 16 (Friesland) months of age (Table 1, Fig. 1).

The *M. semitendinosus* (light area) shows a sharper decrease in the percentage of red fibres from birth to 8 (Afrikaner) and 12 (Friesland) months of age and then stabilizes as the animal matures. The increase in size and decline in number of the red fibres are continued until puberty. From this period on maturity is reached as far as muscle growth changes are concerned.

With the *M. semitendinosus* (dark area) a similar decrease is noted as with the *M. semitendinosus* (light area) from birth to 8 (Afrikaner) and 12 (Friesland) months followed by an increase up to 16 (Friesland) to 20 (Afrikaner) months and then a slight decrease to 24 months.

ii) *Age x muscle*

Insofar as the red muscle fibre percentage is concerned the *M. semimembranosus* and *M. semitendinosus* (light area) show a comparable pattern in the decrease of the percentage red fibres with age. In contrast to this the *M. semitendinosus* (dark area) shows a decrease in red fibre percentage up to 8 (Afrikaner) and 12 (Friesland) months only and then an increase again to 16 (Afrikaner) and 20 (Friesland) months of age with a slight decrease indicated towards 24 months (Table 1, Fig. 1).

Table 1

Analysis of variance results of muscle fibre types of the M semimembranosus, M. semitendinosus *(dark) and* M. semitendinosus *(light) of Afrikaner and Friesland bulls of ages between birth and 24 months*

Parameter	A (Breed)	B (Age)	C (Muscle)	AB	AC	BC	ABC	CV %
	F-values							
Percentage red muscle fibres	2,53	9,35 **	79,18 **	1,39	0,41	3,84 **	0,52	14,69
Percentage intermediary muscle fibres	0,04	3,05 *	6,81 **	3,78 **	0,61	1,70	0,29	33,58
Percentage white muscle fibres	1,43	6,33 **	57,10 **	4,44 **	1,51	2,16 *	0,71	16,91

Fig. 1 *Percentage red and white muscle fibres in the muscles of bulls (Red – Age; P <0,01; Muscle: P <0,01; Age x muscle: P <0,01; White – Age: P < 0,01; Age x muscle: P <0,05; Breed x age: P <0,01)*

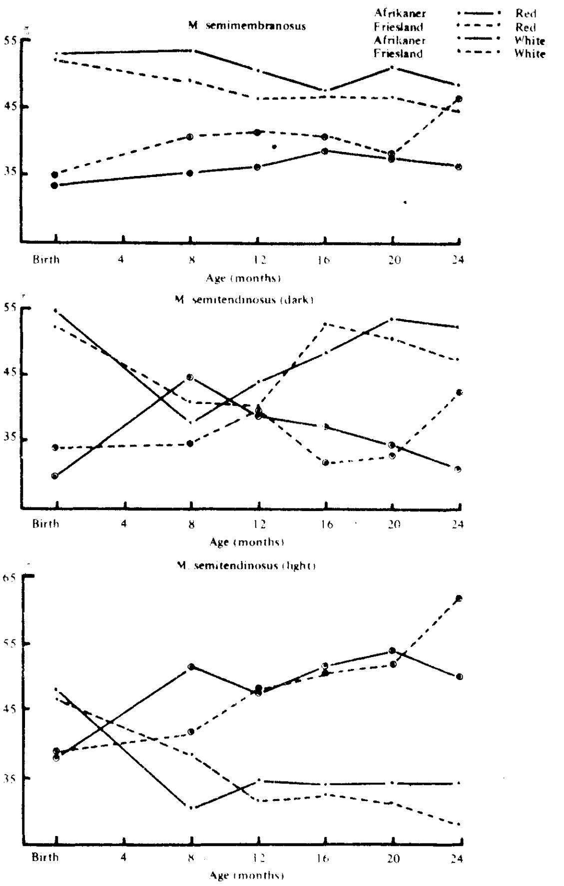
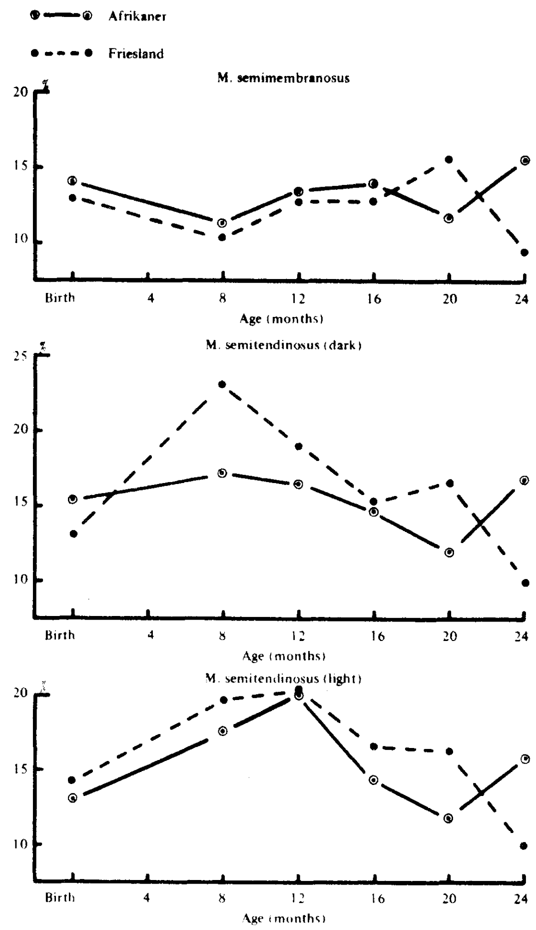


Fig. 2 *Percentage intermediary muscle fibres in the muscles of bulls (Age: P < 0,01; Muscle: P < 0,01; Breed x age: P <0,01)*



The action of the *M. semitendinosus* according to Sisson (1967) is to extend the hip and hock joints acting together with the *M. biceps femoris* and *M. semimembranosus* to propel the trunk forward and allow the animal to rear. The young and vigorous male animal is usually engaged in testing its strength against an opponent by continual jostling and pushing. Rearing for copulation or simulated copulation with another male brings this muscle into action. For sustained action of this type the red muscle fibre is required. In both breeds the tendency is observed for the initial decline of the percentage red fibres in the *M. semitendinosus* (dark) and the subsequent increase of these fibres from 8 (Afrikaner) and 12 (Friesland) months onwards.

Observations on the percentage of red muscle fibres show a decrease between birth and 12 months of age for all 3 muscles concerned. This decrease can be attributed to the fact that a percentage of these red fibres are converted to white fibres through the intermediary stage. There is a highly significant increase (P <0,01) in in the percentage red muscle fibres of the *M. semitendinosus* (dark area) with a muscle x age interaction. This increase coincides with the onset of puberty and is maintrained for the period 16 to 20 months after which a slight decrease sets in towards 24 months. No difference is found between the breeds in the percentage increase or decrease of the red fibres. The same trend is observed for both breeds as the animals grows older.

Differences between the muscles in the percentage red fibres are found between the *M. semitendinosus* (dark area) and *M. semimembranosus* with approximately 48% red fibres on one hand and on the other hand the *M. Semitendinosus* (light area) with approximately 35% red fibres.

Percentage white muscle fibres of bulls

i) *Age*

In the *M. semimembranosus* an increase in the percentage of white fibres is encountered up to 12 (Friesland) to 16 Afrikaner) months of age and this is in keeping with the decrease in red fibre percentage over the same period. Increase in the percentage of white fibres in the *M. semitendinosus* (light area) is practically constant till 20 (Afrikaner) to 24 (Friesland) months which is directly related to the decrease in red fibre percentage (Table 1, Fig. 1).

The tendency for the percentage of white fibres in the *M. semitendinosus* (dark area) to increase from birth to 8 (Afrikaner) to 12 (Friesland) months and then to show a continuous decrease is exactly the converse of the trend shown by the red fibres. This is distinctive for the pattern of red fibre variation especially in the Afrikaner.

An initial increase in the percentage of white fibres from birth to 8 and 12 months followed by a decrease and the reverse in the case of the red fibres is either an atypical or unique growth phenomenon of this muscle area.

ii) *Age x breed*

Between ages 20 and 24 months there is a sudden increase in the percentage white muscle fibres in the Friesland but not in the Afrikaner (Table 1, Fig. 1).

iii) *Age x muscle*

The *M. semimembranosus* and the *M. semitendinosus* (light area) show the same gradual increase in the percentage of white fibres with age but the *M. semitendinosus* (dark area) shows an initial increase followed by a continuous decrease in the Afrikaner, while the Friesland shows an increase from 16 months onwards. This is effected in the latter muscle by the converse pattern of change in the red muscle fibres (Table 1, Fig. 1).

From the data it can be gathered that there is an increase in the percentage of white fibres with an increase in age. However, the decrease in the percentage of red fibres is more drastic than the increase in the percentage of white fibres. It seems that the transition from red fibres to intermediary fibres buffers the rate at which the intermediary fibres pass into white fibres. The increase in white fibre percentage is more gradual on this account. As the percentage of red fibres decrease and increase so the percentage of white fibres increase and decrease and a muscle x age interaction is noted.

Percentage of intermediary fibres of bulls

i) *Age*

The *M. semimembranosus* shows a decrease in the percentage of intermediary fibres from birth to 8 months of age followed by a gradual increase. In the *M. semitendinosus* (light area) it is observed that an increase in the percentage of intermediary fibres occurs from birth to 12 months and is followed by a decrease. The *M. semitendinosus* (dark area) follows the same pattern as the *M. semitendinosus* (light area) but it is not as pronounced (Table 1, Fig. 2). According to these observations it would appear that the *M. semimembranosus* is maturing at a slightly slower rate than the *M. semitendinosus* (both areas). This fits in with the funtions of the *M. semitendinosus* as the major muscle in extending the hip and hock joint.

ii) *Age x muscle*

The *M. semitendinosus* (light and dark area) exhibits an initial increase followed by a decrease in contrast to the *M. semimembranosus* which shows an initial decrease before an upward trend is noted (Table 1, Fig. 2).

iii) Breed x age

The Friesland and Afrikaner display reverse trends for the period between 20 and 24 months for the percentage of intermediary fibres; otherwise they seem to follow the same pattern for identical muscles (Table 1, Fig. 2).

Concerning the similarity between the percentages of the intermediary and white fibres, the *M. semimembranosus* and the *M. semitendinosus* (dark area) appear to react identical but in the case of the *M. semitendinosus* (light area) this tendency only occurs between birth and 12 months of age and then shows an opposite trend.

When considering the intermediary fibres as a transitional stage between red and white fibres the percentage coefficient of variation elucidates the matter. At 34% in the case of the intermediary fibres it is much higher than the 14% for the red fibres or the 17% of the white fibres. It is more difficult to assess whether a fibre is an intermediary than when it is either white or red. This could be the reason for the differences in the coefficient of variation (Table 1).

Percentage of red and white muscle fibres of bulls and steers.

i) *Breed*

In all three muscles studied it was observed that the Friesland had a larger percentage of white and a smaller percentage of red muscle fibres than the Afrikaner (Table 2, Fig. 3). These differences were statistically significant for the percentage of white fibres of the *M. semimembranosus* ($P < 0{,}05$) and the red fibres of the light area of the *M. semitendinosus* ($P < 0{,}01$).

Cronjé (1976) in his studies on the same material established that the muscles of the Afrikaner had a higher haematin-iron pigment content than the corresponding muscles of the Frieslands. This brought him to the conclusion that the Frieslands have a higher anaerobic muscle metabolism than the Afrikaner.

The Friesland, as a breed, is a faster grower and sexually earlier developer than the Afrikaner (Cronjé, 1976) and shows in the larger number of white muscle fibres it possesses that it has a higher anaerobic muscle metabolic rate than the Afrikaner.

ii) *Castration*

The *M. semitendinosus* (light area) and the *M. semitendinosus* (dark area) of the bulls contain a larger percentage red and a smaller percentage white fibres than those of the steers (Table 2, Fig. 4).

Generally speaking the data of Cronjé (1976) indicates that the muscles of bulls contain more pigment (myoglobin) than those of the steers pointing to a more aerobic metabolism which fits in with the observation that there is a higher percentage of red fibres in the muscles of the bulls than in those of the steers.

The *M. semimembranosus* shows the same tendency in the Afrikaner where the bulls have a larger percentage red fibres in their muscles than the steers but in the Friesland the converse is found which also tallies with the muscle pigment analysis of this muscle in the study of Cronjé (1976).

Table 2

Analysis of variance results of muscle fibre types of muscles of Afrikaner and Friesland bulls and steers of ages between 12 and 24 months

Parameter	F-values A (Breed)	B (Sex)	C (Age)	AB	AC	BC	ABC	CV %
M. semimembranosus (% Red muscle fibres)	2,29	0,28	0,35	0,40	0,02	0,14	0,54	13,15
M. semimembranosus (% Intermediary muscle fibres)	0,97	0,10	0,23	0,00	0,80	0,02	1,22	33,36
M. semimembranosus (% White muscle fibres)	5,94 *	0,37	1,03	1,34	0,64	0,19	1,86	12,94
M. semitendinosus (dark) (% Red muscle fibres)	3,22	0,05	3,53	0,71	1,53	0,83	0,57	14,57
M. semitendinosus (dark) (% Intermediary muscle fibres)	2,27	0,58	1,17	1,70	3,30 *	0,40	0,60	33,35
M. semitendinosus (dark) (% White muscle fibres)	0,58	0,58	1,42	0,00	2,65	0,50	0,74	18,84
M. semitendinosus (light) (% Red muscle fibres)	9,55 **	6,95 *	0,71	0,37	0,86	0,16	0,15	19,03
M. semitendinosus (light) (% Intermediary muscle fibres)	0,41	2,62	2,45	0,15	0,79	1,52	1,20	35,40
M. semitendinosus (light) (% White muscle fibres)	3,84	10,71 **	2,78 *	0,26	1,88	0,31	0,43	12,99

Fig. 3 *Percentage white and red muscle fibres in the muscles of both sexes of 8 to 24 months of age. SM:* M. semimembranosus; *ST (D):* M. semitendinosus *(dark); ST (L):* M. semitendinosus *(light)*

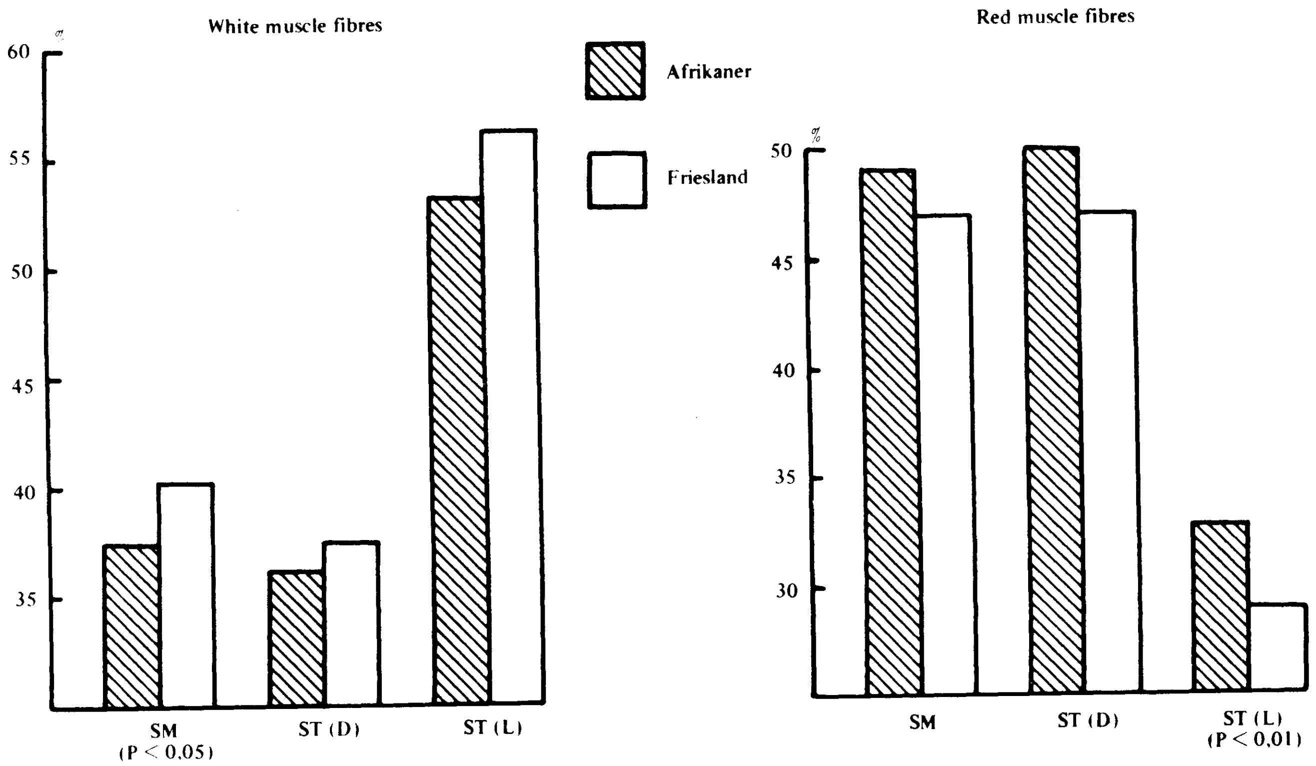
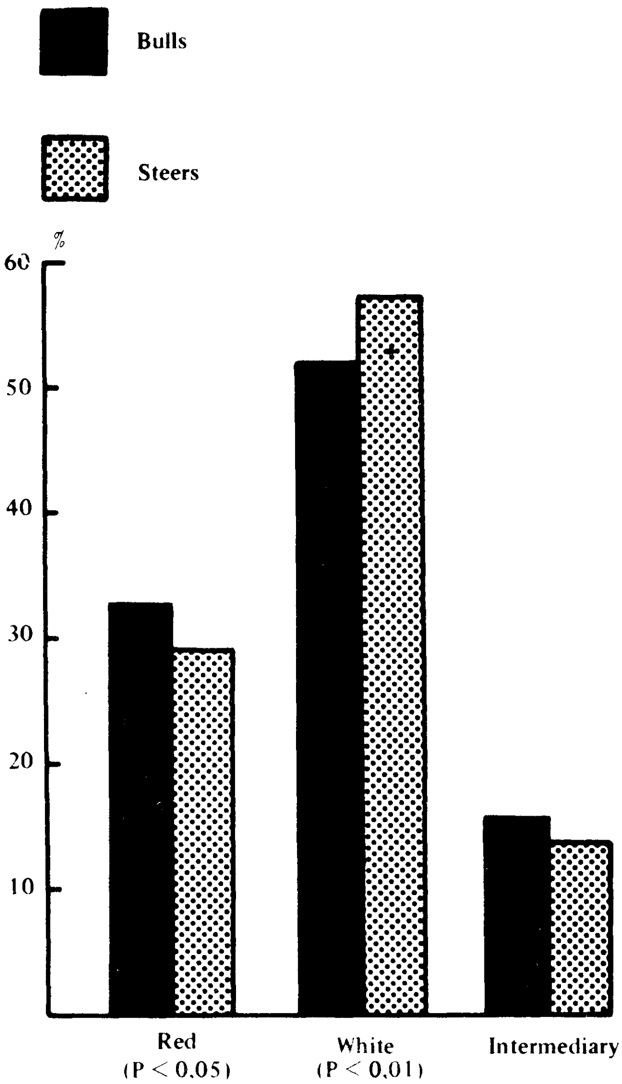


Fig. 4 *Percentage red, white and intermediary muscle fibres in the* M. semitendinosus *(light) of both breeds of all ages*



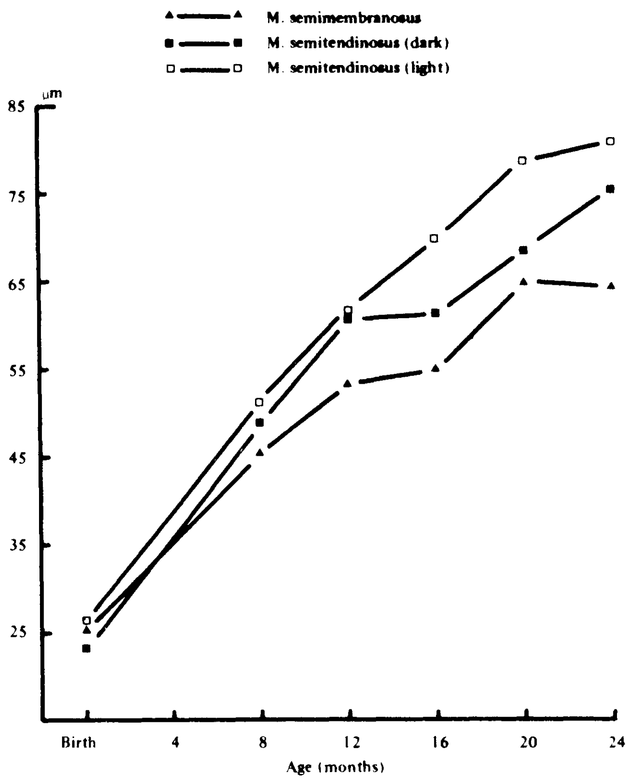
MUSCLE FIBRE DIAMETER

Muscle fibre diameter of bulls

i) *Age*

Fibre diameter increase follows a distinctive pattern for the 3 muscles concerned. The *M. semimembranosus* and the *M. semitendinosus* (dark area) show a sharp increase in fibre diameter up to 12 months of age and then tapers off. The *M. semimembranosus* increases

Fig. 5 *Muscle fibre diameter (µm) of the muscles of bulls of both breeds (Breed: $P < 0,01$; Age: $P < 0,01$; Muscle: $P < 0,01$; Age x muscle: $P < 0,01$)*



from 25 µm at birth to 64 µm at 24 months, the *M. semitendinosus* (dark) from 23 µm to 75 µm and the *M. semitendinosus* (light) from 27 µm to 80 µm.

This coincides with the pattern of change in the percentage of white fibres. In the case of the *M. semi tendinosus* (light area) this increase is maintained up to the age of 20 months before tapering off which corresponds to the increase in the percentage of white fibres in the same muscle to the same age (Table 3, Fig. 5). While the fibres of the 3 muscles had approximately the same diameter up to 8 months of age differences in size only became apparent after this period. A differential growth rate following this phase results in the size differences in the fibre types of these 3 muscles.

ii) *Muscle*

White muscle fibres have a larger diameter than red muscle fibres and the *M. semitendinosus* (light area) has

Table 3

Analysis of variance results of muscle fibre diameter (µm) of muscles of Afrikaner and Friesland bulls of ages between birth and 24 months

F-values

A (Breed)	B (Age)	C (Muscle)	AB	AC	BC	ABC	CV %
14,87 **	251,70 **	39,18 **	1,34	1,23	3,36 **	0,94	3,44

a significantly higher percentage of white fibres than the *M. semimembranosus* and *M. semitendinosus* (dark area) (55 : 38: 36%). The *M. semitendinosus* (light area) with its higher percentage of white fibres has a larger mean muscle fibre diameter than both the *M. semimembranosus* and *M. semitendinosus* (dark area) which has a lower percentage of white fibres (Table 3, Fig. 5).

iii) *Age x muscle*

The *M. semitendinosus* (light area) shows a continuous increase in fibre diameter up to 20 months of age coinciding with the percentage change of fibre type while the *M. semimembranosus* and *M. semitendinosus* (dark area) has a slower rate of diameter increase from 12 months onwards which can also be directly related to the percentage of red and white muscle fibres changes with age (Table 3, Fig. 5).

iv) *Breed*

The smaller diameter of the muscle fibres of the Afrikaner bull can be related to the fact that the Afrikaner has a lower body mass and hence a lower muscle mass than the Friesland (Cronjé, 1976). This is reflected in the fibre diameters of all three muscles (Table 3, Fig. 6).

Muscle fibre diameter of bulls and steers

Castration

Due to the mass advantage of bull over steer (Cronjé, 1976) the muscle fibre diameter of the muscles of the bull are larger than those of the steer despite the fact that the bulls had a lower percentage white fibres (Table 4, Fig. 7).

Conclusions

In a recent review of the metabolic and functional properties of skeletal muscle in relation to meat quality, Heffron (1973) summarized certain muscle metabolism characteristics such as aerobic and anaerobic muscle fibre types which could affect the water-holding capacity, tenderness and colour of meat. Much of this information is available for laboratory animals as well as the pig, but research results regarding the muscle metabolism of the bovine is rather limited.

The result of a selection programme for growth rate is increased muscularity which is evident from larger sized muscles with increased muscle fibre size. An increase in the proportion of white relative to red muscle fibres in concomitant with an accelerated increase in muscle mass and because of the larger mean muscle fibre size of muscles containing more white muscle fibres. The relationship between intensive selection for growth rate, muscularity, anaerobic muscle metabolism, white muscle fibre content of muscles, stress susceptibility of animals and deterioration of certain meat quality attributes has been well illustrated with pigs.

Fig. 6 *Muscle fibre diamter (μm) in the muscles of bulls of all ages. SM:* M semimembranosus; *ST (L):* M. semitendinosus *(light); ST (D):* M. semitendinosus *(dark) (Breed: P < 0,01; muscle: P < 0,01)*

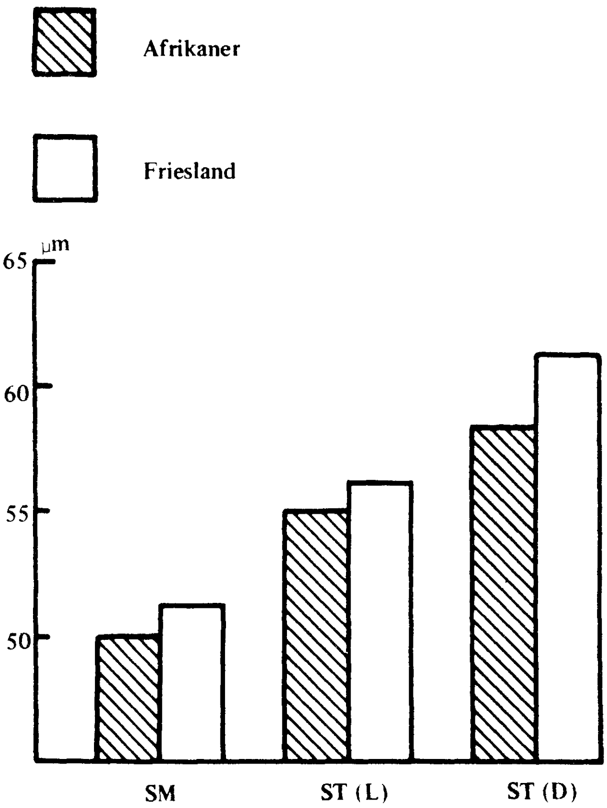


Fig. 7 *Muscle fibre diameter (μm) of the muscles of animals of 8 to 24 months of age (Afr: Afrikaner; Fr: Friesland)*

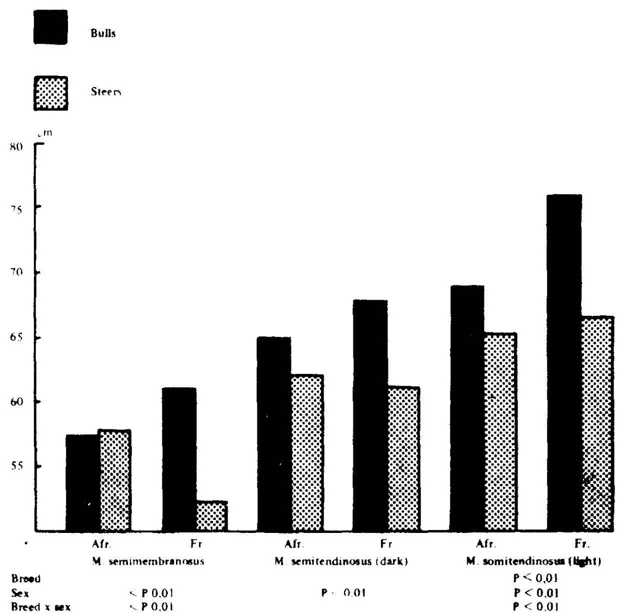


Table 4

Analysis of variance results of muscle fibre diameter (μm) of muscles of Afrikaner and Friesland bulls and steers of ages between 12 and 24 months

Parameter	A (Breed)	B (Sex)	C (Age)	AB	AC	BC	ABC	CV %
	F-values							
M. semimembranosus	0,46	9,23 **	12,73 **	10,96 **	0,83	1,24	1,16	7,84
M. semitendinosus (dark)	0,33	9,49 **	10,29 **	1,58	0,65	2,13	0,93	8,58
M. semitendinosus (light)	8,14 **	20,90 **	23,40 **	4,15 **	2,05	2,61	2,38	8,15

In the present study certain observations of muscle metabolism characteristics have been made which could well have a bearing on meat quality.

Histologically no particular grouping of red and white muscle fibres into definite patterns could be observed in sections of muscle of either breed. According to Ashmore & Addis (1972) the β-red fibres are the first to develop and remain the red fibre throughout the life-span. Around these fibres the α-red fibres develop which later change into the intermediaries and finally into the α-white fibres. The most common pattern to expect in the fibre bundle of an animal would be the chequer-board pattern.

Changes that occur in the percentage of fibre types between birth and 12 to 16 months of age show a gradual shift from red to white fibre types. This can be related to the growth of the normal animal. The speed with which the changes take place will be an indication of increase in size of the individual muscles.

The muscle fibre size of the different muscles studied varied between the *M. semimembranosus* and *M. semitendinosus* (dark area) where a sharp increase in fibre diameter was noticed up to 12 months of age and then a tapering off. The light area of the latter muscle had a high proportion of large white fibres and an increase of fibre diameter up to 20 months of age before tapering off. This could lead to the observation that the light and dark areas of the *M. semitendinosus* has a differential growth rate as far as muscle fibre diameter is concerned. Differences in fibre diameter may well be implicated when differences in meat quality between muscles of the same carcass are to be explained.

The important influence of age, muscle type, breed and the effect of castration on the percentage and diameter of the fibre was demonstrated in this study. In his review Heffron (1973) concluded that "present evidence, although indirect in most respects, suggests that a desirable meat producing species should be physiologically oriented to a highly aerobic muscle metabolism . . .".

Muscles of young animals are metabolically more aerobic than those of older animals, the muscles of bulls have a higher proportion of aerobic fibres than steers and Afrikaner cattle have more red and less white muscle fibres in comparison to the muscles of Friesland cattle. The results of Boccard *et al* (1977) on these same animals showed that the muscle collagen of younger animals was more soluble and the meat more tender and that muscles of Afrikaner cattle had a higher solubility of muscle collagen than in the case of Friesland cattle. Different biological characteristics of the meat producing animal therefore fortunately seem not to have contrasting effects on the various important meat quality characteristics.

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References

ASHMORE, C.R. & ADDIS, P.B., 1972. Prenatal development of muscle fibre types in domestic animals. *Proc. 25th Annual Meat Conf. of AMSA* 211.

BARKA, T. & ANDERSON, P.J. 1963. Histochemistry, theory, practice and bibliography – Hoeber Medical Division, *Harper & Raw, Publishers, Inc. London.*

BOCCARD, R.L., NAUDÉ, R.T., CRONJÉ, D.E., SMIT, MARIA C. VENTER, H.J. & ROSSOUW, ELLENOR, 1977. In press.

CRONJÉ, D.E., 1976. Die invloed van ras, geslag en ouderdom van beeste op sekere vleiskwaliteitseienskappe met meer spesifieke verwysing na die invloed van kollageen op vleistaaiheid. M.Sc. tesis, Univ. van Stellenbosch, Stellenbosch, R.S.A.

DREYER, J.H., NAUDÉ, R.T. & GOUWS, P.J., 1972. The influence of slaughter technique and histological treatment on muscle fibre diameter of low and high pH, pork muscle. *S. Afr. J. Anim. Sci.* 2, 109.

DUBOWITZ, V. & PEARSE, A.G.E., 1960. Reciprocal relationship of phosphorylase and oxidative enzymes in skeletal muscles. *Nature.* 185, 701.

HEFFRON, J.J.A., 1973. Metabolic and functional properties of skeletal muscle in relation to meat quality. *Jl. S. Afr. vet. Ass.* 44, 119.

HUNT, M.C. & HEDRICK, H.B., 1977. Histochemical and histological characteristics of bovine muscles from four quality groups. *J. Food Sci.*, 42, (2), 578.

JAMES, N.T., 1971. The distribution of muscle fibre types in fasciculi and their analysis. *J. Anat.* 110, 335.

MALATY, M.A. & BOURNE, G.H., 1953. Histochemistry of succinic dehydrogenase. *Nature,* 171, 295.

MOODY, W.G. & CASSENS, R.G., 1968. Histochemical differentiation of red and white muscle fibres. *J. Anim. Sci.* 27, (4), 961.

MORITA, S. CASSENS, R.G. & BRISKEY, E.J., 1969. Localization of myoglobin in striated muscle of the domestic pig: Benzidine and $NADH_2$-TR reactions. *Stain Tech.* 44, (6), 283.

OGATA, T. & MORI, M., 1964. Histochemical study of oxidative enzymes in invertebrate muscles. *J. Histochem. & Cytochem.* 12, 183.

SISSON, S.B., 1967. *The Anatomy of Domestic Animals* 4th Edn.: W.B. Saunders, Co., Philadelphia & London.

SNEDECOR, G.W. & COCHRAN, W.G., 1966. *Statistical Methods* 5th Edn.: Iowa: Iowa State University Press.

WEST, R.L., 1974. Red to white fibre ratios as an index of double muscling in beef cattle. *J. Anim. Sci.*, 38, (5), 1165.