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Since a long time practical experience has shown a wide variation in tenderness of muscles ,specially in cattle , between and within animals.Up to now variation between animals has been mostly studied to explain the influence of breed , age , carcass weight or feeding conditions.Toughness measurement is ,as routine control , included, for this reason ,in many experimental procedures.

The variation of tenderness among the different muscles of the carcass has not been thoroughly studied ,in spite of the major influence of this character upon prices of meat cuts .This problem is mainly important in such countries like France ,where meat consumption is more and more directed towards types of meat sufficiently tender to be used as steak or roast.At the moment we lack for this type of meat in our market ,so that we are obliged to import , though the total meat production would be sufficient quantitatively for our needs.Thus ,in our conditions, we must consider that each carcass , whatever is its origin , is more or less deficient as to its ability to produce the tender meat we need.

This can explain the special method of cutting beef carcasses used in our country.Butcher's work may be partly considered like a dissection ,during which the craftman may and must separate among one hundred of muscles per half carcass parts of them which can really be used as tender meat and sold in consequence.

In these conditions , tenderness evaluation of the different muscles of cattle carcass is of prime importance in the definition of carcass quality .At the moment ,if apparatus (like Warner-Bratzler shear force apparatus) are available to measure toughness of different muscles , no concept have been proposed to assess this characteristic ,on the whole , at the level of the total carcass. This note reports some preliminary results obtained on this problem by considering the muscle Longissimus dorsi in two types of cattle, cows and young bulls.

EXPERIMENTAL

In a first time 13 cows of Frisian breed were studied .They had similar conformation and fatness and varied greatly in age (average 79,8 ± 31,6 months old , with a range from 30 to 145 months). Toughness of muscles was measured after 7 days of ageing ,at + 2° C. The following muscles were studied : psoas major , adductor, longissimus dorsi , triceps brachii caput longum , teres major , semi tendinosus ,splenius, pectoralis profundus , triceps brachii caput laterale , rhomboideus.One slice of 15 mm depth of each muscle was cut , according to a standardized procedure (cutting in the middle part of the muscles for all the muscles ,except for longissimus dorsi where the cut was made at the level of the third lumbar vertebra ,and for psoas major cut at the level of the fourth lumbar vertebra.On each slice eight to twelve cores of half inch diameter were obtained and toughness was measured with the Warner - Bratzler apparatus.

A similar procedure was adopted with young bulls which were nine of Normande breed and nine of Frisian breed.They were 16 to 18 months old .Their muscles were considered after a delay of ageing ,varying from 5 to 7 days ,according to the muscles.

MEAT TOUGHNESS INDEX OF BEEF CARCASSES

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RESULTS AND DISCUSSION

Average values of shear forces for each muscle in both types are shown in Table I. The table II is concerned with the variance analysis of shear forces ,according to muscles and animals.The relationship of toughness index of longissimus dorsi and other muscles are shown in Table III in which are quoted the values of correlation between shear force index of longissimus dorsi and the average shear force index of the ten muscles studied by animal.In Table IV are the values of correlation between toughness of longissimus dorsi and that of each nine other muscles.

There exists a significant effect of the nature of muscle upon shear force variation .The interaction muscle-sex is high , which may mean that the effect of sex is not the same for each muscle .In addition one observes a very important variation of indexes between animals ,for each muscle.

Variation among muscles is not surprising , because the muscles have been partly choosed on their assumed differences in toughness. From these results it is possible to set a hierarchical order of the ten muscles , as tenderness is concerned.It is probably important to note that this order is not the same for cows and young bulls.Too , the shear force indexes of each muscle are quite different between the two types , except for the semi tendinosus and the teres major muscles.

The important variation between the same type of muscle of the different animals can be partly explained by the general variation of toughness which existed between animals .The average shear force index , calculated from the mean of the ten muscles was 5,13 $\pm$ 1,07 kg in cows and 5,22 $\pm$ 0,71 kg in young bulls.The range of this average index was from 3,27 to 7,01 kg for cows ,and 3,78 to 6,30 kg for young bulls.

But a certain part of the variation is independent and seems to be aleatory.As examples one can consider the values of shear forces of individual muscles for the more tender and the less tender animals in cows and in young bulls (Table V).

This situation makes doubtful the meaning of this average index of toughness and questionable its use.

The principle of one average index of toughness had been evolved by assuming than in the hypothesis of a rather uniform (constant or proportional) increase of toughness of the different muscles ,a small but sufficient number of them will be necessary to establish this index .In fact , as shown in Table III the relationship between values of the average index and the index of each muscle are variable (and different in each of the two types of animals).

It is well known among meat research workers that the muscle longissimus dorsi is an experimental muscle , widely used (and very often the only one considered in the studies) .Ease of its obtention may be the reason of this privileged position in minds of research workers and in experimental procedures.Nevertheless ,its predictive value of toughness of other muscles seems not very satisfactory in cows and ,mainly , in young bulls.

From these preliminary results one can conclude that there exists between muscles large differences of toughness , which are larger in cows than in young bulls. Toughness variation ,between animals , of each muscle seems relatively aleatory.For that reason it is not possible to propose a general toughness index rather simple.

The same type of work might be applied to other types of meat production and consider more muscles.

The predictive value of longissimus dorsi is not very satisfactory As to the origin of toughness ,these results suggest that muscles show a variable susceptivity to the influences of different factors which affect toughness .This point might be cleared up rather quickly because the unexpected variation in tenderness causes many troubles in meat trade ,specially in our country where the butcher is becoming more and more a "tender meat digger" , for whom tenderness is quite synonym of profit.

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TABLES

TABLE I - Shear force index (kg) of different muscles

Muscle	Young bulls N = I8		Cows N = I3	
	$\bar{x}$	σ	$\bar{x}$	σ
Psoas major	3,27	0,64	2,35	0,40
Adductor	3,00	0,92	2,42	0,59
Longissimus dorsi	4,I5	0,9I	2,66	0,72
Triceps brachii (caput longum)	4,67	I,05	4;I5	I,I9
Teres major	4,85	I,I3	4,60	I,08
Semi tendinosus	6,I0	I,06	5,86	0,76
Splenius	4,I9	0,98	6,9I	2,85
Pectoralis profundus	8,05	2,4I	7,38	2,22
Triceps brachii (caput laterale)	8,80	2,25	7,38	2,28
Rhomboideus	5,I2	I,36	7,56	2,22

TABLE II - Components of variance of shear force index

Source of variation	Degrees of freedom	Mean squares
type of animal (cow or bull)	I	0,653
muscle	9	II0,448
type × muscle interaction	9	I6,328
animals	290	2,263

TABLE III- correlation between shear force index of each muscle and the average index of the ten muscles

muscle	young bulls	cows
Psoas major	.59	.50
Adductor	.63	.69
Longissimus dorsi	.62	.7I
Triceps brachii (caput longum)	.49	.87
Teres major	.36	.23
Semitendinosus	.80	.72
Splenius	.29	.8I
Pectoralis profundus	.56	.83
Triceps brachii (caput laterale)	.7I	.77
Rhomboideus	.39	.87

TABLE IV - correlation between shear force index of longissimus dorsi and other muscles

muscle	young bulls	cows
Psoas major	.32	.66
Adductor	.II	.53
Triceps brachii (caput longum)	.65	.72
Teres major	- .05	.37
Semitendinosus	.45	.29
Splenius	.47	.4I
Pectoralis profundus	.3I	.57
Triceps brachii (caput laterale)	.I8	.43
Rhomboideus	.40	.58

TABLE V - Shear force index of individual muscles in less tender and more tender animal

muscle	young bulls		cows	
Psoas major	2,39	3,74	2,42	3,00
Adductor	2,57	5,I4	I,29	3,02
Longissimus dorsi	I,9I	4,6I	I,88	3,80
Triceps brachii (caput longum)	3,33	4,92	I,92	6,8I
Teres major	2,84	5,88	5,0I	4,36
Semitendinosus	4,53	7,I4	4,0I	5,83
Splenius	2,70	5,40	4,39	II,85
Pectoralis profundus	5,I7	7,99	3,93	9,58
Triceps brachii (caput laterale)	3,47	I2,05	4,35	I0,49
Rhomboideus	4,8I	6,II	3,48	II,35