Some characteristics of raw and cooked porcine muscles of pure and crossbreed animals

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The selection of pigs causes the increase of the musculature quantity, but the characteristics of the muscles are changing as well. Besides the well known data of Zorn (1954) on the weight increase of mature pigs in the period from 1900 to 1950, there are numerous data on the increase of muscle, and decrease of fatty tissue quantity, achieved during the last several decades of selection.

Unshelm et al. (1971) have investigated several characteristics of pigs of different breeds (German Landrace, Pietran, German pasture, Mangulica, Göttingen Miniature) and, among other, have found that pigs of selected breeds grow faster and their musculature is more developed than in the primitive ones, but their meat is of poorer characteristics. Similar investigations were performed by Rahelić et al. (1978) and they have reported similar data by investigating other types of pigs of different selection stage (Mangulica /M/, Slavonian Black /BS1/, Swedish Landrace /SL/, Yorkshire /Y/). A characteristic indicator of the features of these pigs' meat is the fact that longissimus dorsi muscle of the M and BS1 pigs releases spontaneously no water, while the Y pigs release 0,7% and the SL 1,19% water.

Today is generally accepted that the meat quality of selected pigs is decreasing with the increase of the musculature quantity (Ludvigsen /1969/, Steinhauf /1969/, Vas and Sybesma /1972/, Charpentier et al. /1972/, Judge /1972/, Sybesma /1976/).

This is, certainly, in close connection with the ratio change of fyber types in the muscles of pigs of different selection stage (as the fiber type is dependent on its physiological function). Namely, all the muscle fibers in the longissimus dorsi muscle of wild-pig are of red type, and their number is decreasing in the following order: Wild-pig (100%) > M (20,6%) > BS1 > Y > SL (15%). However, it must be pointed out that in the muscle of Wild-pig raised under confinement conditions not all fibers are of red type (Rahelić and Puač, 1981).

Lately, multistaged crosses are more and more being bred with the aim of increasing the musculature quantity. There are contradictory data in literature on the influence of crossbreeding of the pig on meat quality. Young et al. (1976) have by crossbreeding established a "significant and favourable heterosis" for some characteristics of pigs, but not for those of the carcass. Goutefongea et al. (1977) have come to a similar finding. Lengerken and Hennebach (1979) have found a small or relatively lower frequency of PSE muscles in hybrids than in purebred pigs, while, Kellner et al. (1978) and Baychev(1980) found a higher frequency of PSE muscles in hybrid pigs.

As this problem is an interesting one, it was decided to carry out preliminary investigations on the meat quality of some purebred pigs and their cross-breeds.

MATERIALS AND METHODS

The muscle characteristics of the following pig breeds were investigated: Swedish Landrace (SL), Dutch Landrace (DL) and the crossbreed pigs Yorkshire (Y) x DL, German Landrace (GL) x DL, three- (I, II, III) and four-breed hybrids (I, II, III, IV). 10 animals from the category "young slaughter-pigs" were investigated from each breed i.d. group. The animals were bred on two farms under similar conditions, transferred into the slaughterhouse one day before the slaughter, and slaughtered and processed in the usual way (electrical stunning) in the same slaughterhouse.

The characteristics of longissimus dorsi muscle were investigated, the part between the 13th and 15th vertebra (LD), semimembranosus muscle, proximal, the lighter part (SM), biceps femoris muscle, lateral part (BF) and triceps brachii muscle, caput longum (TB). pH and the colour were measured instrumentally 45 min post mortem, and pH and the colour instrumentally and sensorily, WHC, cooking loss, tenderness with instruments and sensorially and the juiciness sensorially 24 hours post mortem.

pH was measured by pH-meter GRONERT-ULTRA X, type TM 5. The colour was determined with the Göfo photometer on the fresh surface of the muscle, and the WHC with the compression method by Grau and Hamm (1953).

Weight-loss was determined by cooking samples of 150 g at the temperature of 90°C for 60 min. The tenderness of the cooked samples was measured with Warner Bratzler shear press, and expressed as the mean value of 8 individual measurements of the force needed for the cutting of samples. The samples were taken in the direction of muscle fibers and their diameter was 1/2 inches.

The sensory evaluation of tenderness and juiciness was carried out by three qualified persons using a score system of 9 points, according to which the extremely tough i.d. dry sample was graded with the mark 1, the optimal one with 7, and the extremely tender i.d. juicy with 9.

RESULTS

There were no significant differences among the weights of live animals of the investigated groups of pigs, the yields as well as the back- and sacrum fat thickness.

The muscle characteristics were different inside the groups of investigated pigs as well as among the groups.

The analysis of the incidence sequence of the same muscle characteristics of the pig groups investigated shows that the primary characteristics for longissimus dorsi muscle is that the muscles of three- and four-breed crosses have the lowest pH_1 and pH_{24}, the lightest $colour_1$ and $colour_{24}$ (Göfo), as well as visually determined, the poorest WHC and the highest cooking drip. On the other side, they are (mostly) the tenderest and the most juicy ones. SL pigs have the toughest and driest muscles though the pH_1 is the highest, pH_{24} is very high and the cooking drip is almost the lowest.

The ratios of semimembranosus muscle characteristics between the pig groups investigated are somewhat differing from the ones of longissimus dorsi muscle. Namely, this muscle is in the three- and four-breed crosses also, mostly, the softest and most juicy, with the lowest pH_{24} and WHC and the biggest cooking drip. But the muscle is of lighter colour in all pig groups, being lighter in three- and darker in four-breed crosses.

The significance of the differences between the investigated muscle characteristics of four-breed crosses and groups i.d. breeds and crosses is shown in table 1.

The data given in table 1 show that pH_1 and pH_{24} of all muscles of four-bred crosses differ significantly from the pH of almost all muscles of SL, DL, YxDL and GLxDL pigs, but not from the pH of the muscles of three-breed corsses. Contrary to the pH differences, the muscle colour of the four-breed crosses is not differing significantly in most cases from the one of other groups of pigs, with the exception of $colour_1$ of LD muscle and $colour_{24}$ (instrumentally and visually) of BF muscle.

The data presented in table 1 show that there are no significant differences in the cooking loss between the muscles of four- and three-breed crosses, but there are differences of this characteristic between all the muscles of four-breed crosses and SL pigs and YxDL crosses, as well as between two muscles (SM and TB) of four-breed crosses and DL and GLxDL pigs. WHC is not significantly differing between the four-breed crosses and SL pigs, but is significantly differing from the other groups of pigs. On the contrary, one can say that the difference between the tenderness and juiciness of the muscles of the four-breed crosses and other groups of pigs is not expressed, with the exception of SL pigs, where the LD and BF muscles are significantly tougher.

Table 2 presents the percentage frequency of PSE and DFD incidence determined so that the number of PSE and DFD changes of all four muscles being expressed as the percentage of the examined ones.

Results of the investigations of the characteristics and the significance level of differences between four muscles of four-breed crosses and other pig groups (n=10)

Table 1.

Characteristic	Muscle	Results and significance of level					
		4X	SL	DL	YxDL	GLxDL	3X
pH_1	LD	5,615	6,275 xx	6,160 xx	6,190 xx	6,040 xx	6,005 x
	SM	5,895	6,360 xx	6,210	6,110 x	6,265 x	6,185
	BF	5,850	6,440 xx	6,260 x	6,250 x	6,300 xx	5,920
	TB	5,795	6,295 xx	6,215 xx	6,065	6,290 xx	6,015
pH_{24}	LD	5,335	5,495	5,585 xx	5,710 xx	5,495	5,375
	SM	5,405	5,440	5,495	5,655 xx	5,480	5,395
	BF	5,415	5,640 x	5,745 xx	5,495 xx	5,680 xx	5,370
	TB	5,580	5,875 xx	5,895 xx	6,030 xx	5,990 xx	5,730
$Colour_1$ (Göfo)	LD	68,50	-	76,10 xx	77,30 xx	72,10 xx	75,80 x
	SM	69,60	-	71,60	70,90	68,20	71,80
	BF	70,50	-	73,80	72,90	72,10	73,50
	TB	70,00	-	72,10	71,40	69,20	70,70
$Colour_{24}$ (Göfo)	LD	60,30	-	66,00	69,00	68,80	64,70
	SM	61,00	-	61,30	63,00	63,60	63,80
	BF	59,70	-	66,30 xx	68,10 xx	68,00 xx	61,00
	TB	66,40	-	68,60	67,40	70,90	65,50
$Colour_{24}$,vis.	LD	2,35	3,60	3,45	3,90	3,45	3,40
	SM	2,15	2,95	2,55	2,75	2,55	2,90
	BF	1,90	3,75 xx	3,25 x	3,60 xx	3,70 xx	2,85 xx
	TB	3,90	4,80 xx	4,20	4,45 x	4,40	3,95
WHC (cm^2)	LD	11,180	10,790	8,700 xx	8,840 xx	10,145	12,575
	SM	10,195	9,760	8,470 x	8,980	9,735	12,485 xx
	BF	11,720	10,610	8,610 xx	9,280 xx	9,505	12,265
	TB	9,020	8,590	6,600 xx	7,055 xx	7,595	10,985 xx
Cooking loss(%)	LD	43,636	41,444 x	42,139	41,056 xx	42,269	44,555
	SM	42,354	39,588 xx	40,365 x	39,938 xx	40,296 x	42,486
	BF	44,106	41,743 xx	42,548	39,500 xx	42,957	44,524
	TB	44,731	40,890 xx	41,826 xx	41,026 xx	40,924 xx	45,114
Tenderness,WB (lb)	LD	13,054	15,512	14,845	16,177 x	14,769	11,281
	SM	10,887	11,024	12,704	12,204	12,916	9,306
	BF	15,610	18,016	19,163 x	17,481	18,696 x	12,681 x
	TB	10,785	12,179	10,638	10,565	10,928	9,411
Tenderness, sensorially	LD	6,150	5,000 xx	6,300	6,100	6,000	6,400
	SM	6,300	6,350	6,200	6,350	5,850	6,600
	BF	5,550	3,800 xx	5,200	5,200	4,950	6,150
	TB	6,700	6,300	6,850	6,550	6,650	7,000
Juiciness, sensorially	LD	5,65	4,500 xx	5,350	4,950	5,400	5,950
	SM	6,55	6,750	6,350	5,750 x	6,400	7,150
	BF	6,25	4,500 xx	5,800	6,000	5,900	6,650
	TB	6,35	6,250	6,850	6,400	6,750	7,100 x

x $P < 0,05$ xx $P < 0,01$

The percentage ratio of muscles with PSE and DFD changes in all four muscles established on the basis of pH and colour

Table 2

Change	The criterion of determination	Frequency of changes					
		SL	DL	YxDL	GLxDL	3X	4X
PSE	pH_1 5,9	10,00	23,00	15,00	28,33	32,50	70,45
	$Colour_1$ 66 Göfo units	-	14,42	6,67	16,67	7,50	25,00
DFD	pH_{24} 6,3	5,00	4,80	5,00	10,00	0	0
	$Colour_{24}$ 72 Göfo units	-	12,50	13,33	28,33	5,00	2,27

As can be seen from the presented data (table 2) the frequency of PSE established on the basis of pH_1 is relatively high in GLxDL crosses, higher in three-breed and the highest in four-breed crosses. The frequency determined on the basis of the colour is somewhat differring from the previously mentioned one, but is, again, definitely the highest in four-breed crosses (though it is for approximately 2/3 lower than the one determined on the basis of pH_1). Contrary to the frequency of PSE, the DFD changes are less expressed in all four muscles of three- and four-breed crosses but mostly in GLxDL crosses.

DISCUSSION

It was mentioned in the Introduction that these data are the results of preliminary investigations. Namely, six breeds of pigs were used for the cross-breeding, and only two were investigated. Furhter, the parents of the investigated pigs were not evidented individually but only in groups.

At the beginning of the analysis it should be pointed out that the yield of neither three- nor four-breed crosses is not better than the one of the investigated purebred pigs, neither is the fatty tissue thickness differring significantly from the one of other groups. It was established by the analysis of the muscle characteristics of the investigated pig groups that pH_1 of the muscles of four-breed crosses is significantly lower in all muscles of the other groups of pigs, with the exception of the muscles of three-breed crosses (table 1). The ration between the pH_{24} values of four-breed crosses and other groups of pigs is similar being expressed in a somewhat less number of muscles. This ratio is in agreement with the ratio of weight losses i.d. cooking losses, because the muscles of four- and three-breed crosses release significantly more water during cooking than the muscles of other groups of pigs. It is characteristic that the WHC of two muscles of three-breed crosses is significantly lower than the one of four-breeds, and this characteristic of GL breeds and YxDL crosses is significantly better than of muscles of four-breed crosses. However, the WHC differences between the muscles of four-breed crosses, SL pigs and GLxDL crosses are not significant, with the exception of the TB muscle of GLxDL crosses.

Contrary to these findings, the differences in tenderness and juiciness between the muscles of four-breed crosses and other groups of pigs are not significant, except for two muscles of SL pigs (table 1).

As a result of significant differences between the pH_1 of muscles of four-breed crosses and SL, DL, YxDL and GLxDL pigs, the difference in frequency of PSE changes was established as well, being pronouncedly the highest (70,45%) in the muscles of four-breed crosses (table 2). The frequency of PSE changes is also higher in the muscles of three-breed crosses (32,50%) than in other groups, though it is twice as small as in the muscles of four-breed crosses. This is in agreement with the finding that, mostly, there is no significant difference between pH_1 values of four- and three-breed crosses.

Contrary to the established high PSE frequency in the muscles of four- and three-breed crosses, the DFD frequency is the rearest in the muscles of these groups of pigs.

Besides the higher i.d. high frequency of PSE changes in the muscles of three- i.d. four-breed crosses, the muscles of these groups of pigs often release spontaneously water.

It was established by these investigations that the muscles of three- and four-breed crosses have, mostly, significantly the lowest pH_1 and pH_{24} values and that they release significantly the greatest quantity of water during cooking and have poorer WHC. That is to say, it was established that the meat of these crosses was of the poorest quality. It's reasonable to assume that the established negative characteristics of the muscles of these crosses are the consequence of the influence of Belgian Landrace pigs, used in the last phase of cross-breeding (three- and four-breed crosses). Namely, it is well known that the meat of that breed of pigs is of poor technological characteristics. Accepting that assumption one could presume that the results of these investigations are in agreement with the findings of Young et al. (1976) and Goutefongea et al. (1977) who didn't find that the negative characteristics of the parents' musculature are expressed as heterosis in following generations.

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