Some characteristics of three greatest muscles in pig ham

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Results of the investigation of T_i,pH_i,pH_u, $colour_i$ and $colour_u$ of M.semimembranosus(SM), biceps femoris(BF) and rectus femoris(RF) of the left ham were obtained for 160 pigs of Sweden Landrace breed.For a smaller number of these muscles the content of total pigments (TP) (n=32),WHC (n=4o),cooking loss (n=32),tenderness by Warner-Bratzler shear-press(n=28)as well as the tenderness and juiciness sensorially(n=2o) were determined 24 hours post mortem.

It was statistically proved that the differences between pH_ias well as between pH_u for the investigated muscles are not significant. On the contrary,$colour_i$,$colour_u$ and the content of TP are significantly different for all three muscles ($P < .01$).However,$colour_i$ and $colour_u$ is the darkest in RF,lighter in SM and the lightest in BF,while the content of TP proved to be the greatest in RF and the smallest in SM.

According to WHC,cooking loss,tenderness measured by Warner-Bratzler shear-press as well as according to scores for tenderness and juiciness the RF muscle was proved as the best one (the best WHC,the most tender and juicy),while BF muscle was the worst one.Differences in WHC,tenderness determined instrumentaly and sensorially are significant($P < .01$).Differences in cooking loss and in juiciness between these muscles are insignificant .Differences in cooking loss between these three muscles are insignificant probably due to the great differences between the samples of the same muscle (e.g. for SM samples they vary from 24 - 43 %).

Einige Eigenschaften von drei grössten Muskeln im Schweineschinken

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In der Arbeit wurden die Forschungsergebnisse T_i,pH_i,pH_u,$Farbe_i$,$Farbe_u$ von M.semimembranosus (SM),biceps femoris(BF) und rectus femoris(RF) des linken Schweineschinken bai 160 Schweinen der Rasse Schwedische Landrace dargestellt.Bei der wenigen Muskeln ist 24 Stunden post mortem der Gesamtpigmentgehalt(GP)(n=32),WBV(n=40),Gewichtverlust beim Kochen(n=32),Zartheit mit Warner-Bratzler Apparat(n=28),sowie Zartheit und Saftigkeit senzorisch(n=20) bestimmt.

Statistisch wurde festgestellt ,dass die Unterschiede zwischen pH_i und pH_u der geprüften Muskeln nicht signifikant sind.

Im Gegenteil,$Farbe_i$,$Farbe_u$, sowie der Gehalt von GP, unterscheiden sich in diesen drei Muskeln signifikant ($P < .01$).Aber $Farbe_i$ und $Farbe_u$ ist in RF am dunkelsten,heller in SM und in BF am hellsten,während der Gehalt von GP auch in RF am grössten, in SM am kleinsten ist.

Auf Grund von WBV,des Gewichtverlustes beim Kochen,der mit Warner-Bratzler Apparat gemessenen und senzorisch bestimmten Zartheit und Saftigkeit,wurde der Muskel RF als der beste und BF als schlechteste bewertet. Die Unterschiede im Gewichtverlust beim Kochen und in der Saftigkeit zwischen diesen Muskeln sind nicht signifikant . Die Unterschiede in WBV,der instrumental und senzorisch bestimmten Zartheit zwischen diesen Muskeln sind signifikant($P < .01$). Die Unterschiede im Gewichtverlust beim Kochen zwischen diesen drei Muskeln sind nicht signifikant, weil die Unterschiede zwischen den Proben derselben Muskeln gross sind(z.B. zwischen den Proben SM varieren sie von 24 bis 43 %).

4.6

Quelques propriétés des trois plus grands muscles du jambon des porcs

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Dans cet ouvrage sont exposés les resultats de l'examen de T_i, pH_i, pH_u, $couleurs_i$ et $couleurs_u$ M. semimembranosus (SM), biceps femoris (BF) et rectus femoris (RF) du jambon gauche de 160 porcs, race landrace suédoise. Sur un moins nombre de ces muscles on a détérmine, 24 heures post mortem, le contenu total des pigments (TP) (n=32), retention d'eau (WHC) (n=40), la perte de poids lors de cuisson (n=32), la molesse par l'appareil Warner-Bratzler (n=28), ainsi que la mollesse et la succulence, sensuellement (n=20).

On a constaté statistiquement que les différences entre pH_i et pH_u des muscles examinés ne sont pas significatives. Par contre, la $couleur_i$, $couleur_u$ ainsi que la contenance TP différent significativement dans ces trois muscles ($P < .01$). Cependant, la $couleur_i$ et la $couleur_u$ est la plus foncée en RF, plus claire en SM et la plus claire en BF, pendant que la contenance TP est aussi la plus grande en RF, mais la moindre en SM.

Sur la base de WHC, la perte de poids par cuisson, la mollesse mesurée par l'appareil de Warner-Bratzler, ainsi que sensuellement quand il s'agit de la détermination de la mollesse et de la succulence, le muscle RF était examiné comme le meilleur (le mieux WHC, le plus mou et le plus succulent) et BF le plus faible. Les differences de WHC, le mollesse déterminées par instrument ainsi que sensuellement, entre les muscles, sont significatives ($P < .01$). Les différences concernant la perte de poids par cuisson et la perte de succulence entre ces muscles ne sont pas significatives. Les différences dans la perte de poids par cuisson, entre ces trois muscles ne sont pas significatives probablement du fait que les différences entre les échantillons de mêmes muscles sont grandes (par ex. entre les échantillons SM, varient de 24 à 43%).

Некоторые свойства трех самых больших мускулов свиинного окорка

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В докладе даются результаты испытывания T_i, pH_i, pH_u краски$_i$ и краски$_u$ M.semimembranosus(SM), biceps femoris(BF) rectus femoris (RF) левого окорка I60 породы свинь шведский landrace. На небольшом количестве этих мускулов определялся post mortem общее содержание пигментов(ОП), (n=32), (n=4o) содержание воды(СВ), потеры веса варкой(n=32), мягкость Warner-Bratzler- аппаратом (n=28) а также мягкость и сочность сензорным образом (n=2o).

Статистически утверждено, что разницы между pH_i, pH_u испытываемых мускулов незначительны. Наоборот, краска$_i$, краска$_u$ а также и содержание ОП значительно различаются в этих трех мускулах($P < .01$). Между тем, краска$_i$ и краска$_u$ самая темная в RF, светлее в SM, самая светлая в BF, а содержание ОП самое большое в RF а самое маленькое в SM.

На основании СВ, потеры веса варкой, мягкости измеряемой Warner-Bratzler- аппаратом а также сензорным способом определяемой мягкости и сочности мускул RF оценен самым лучшим(лучший СВ, самый мягкий и самый сочный), а BF самый плохой. Разница СВ, мягкость определяемая при помощи аппаратов а также сензорным способом, между этими мускулами значительна($P < .01$) Разница в потерях веса варкой и в сочности между этими мускулами незначительна. Разница в потерях веса варкой между этими тремя мускулами незначительна, наверно из-за того, что различие между образцами тех самых мускулов большое(например, между образцами SM варьирует от 24 до 43%).

Some characteristics of three greatest muscles in pig ham

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Pig muscles differ one from another by size, shape, chemical composition and physico-chemical characteristics, what is in the most influenced by their functions in the course of animal life. These differences exist, also, between muscles from the same region.
Muscles in pig ham are of various weight. The heaviest is M. biceps femoris (BF) (937, i.e. 1,157 g), a little lighter M. semimembranosus (SM) (683, i.e. 889 g) and still lighter M. rectus femoris (RF) (335, i.e. 389 g), while the other ones are merkedly lighter (Rahelić and Rede, 1969; Miljević, 1971).
According to the data of Topel et al. (1966) and Rahelić and Rede (1969) water content in these three muscles varies from 73.7 to 75.8%, fat content from 1.78 to 3.28% (RF 1.78, i.e. 1.9%, and BF 3.28, i.e. 3.2%). Rahelić and Rede (1969) have established that the content of connective tissue proved to be for the three mentioned muscles as follows: BF 0.54%; RF 0.40% and SM 0.37%. Rejt et al. (1978) have, also, proved significant differences in the content of connective tissue between BF and SM muscles - 1.78 and 3.71% of total proteins.
It is known that the differences in pH and colour for these three muscles are also expressed (Topel et al., 1966; Rahelić and Rede, 1969; Linke et al., 1978) particularly if the muscles are affected by BMV phenomenon (Briskey, 1974). Topel et al. (1966) have proved that the content of Mb in the mentioned muscles, is as follows: BF 5.06; SM 4.05 and RF 5.65 mg/g of dry and defatted muscles. They differ by WHC, too: the best WHC has been observed for RF and the weakest for BF (Topel et al., 1966; Rahelić and Rede, 1969). Rejt et al. (1978) have proved, however, that SM is of better WHC than BF.
Rahelić and Rede (1969) quote that the tenderness of ham muscles varies from 0.46 to 0.71, and for BF amounts 0.62 the toughest, SM 0.59 and RF 0.54 the most tender. Rejt et al. (1978) have proved that muscle BF releases in the cours of cooking more water than SM, and that the former is more tender than the latter one.
While in literature there are some data on the characteristics of muscles in pig ham which indicate differences between these traits, there are hardly any on the traits of cooked muscles. As these muscles are used for the production of canned hams, being one of the most important products of meat industry, we have decided to examine some of the traits of these three greatest, raw and cooked muscles of pig ham.

Material and Methods

For the carried investigations we have used SM, BF and RF muscles of the left ham of 160 pigs, of Sweden Landrace breed. Pigs were of 6 to 7 months old, weighing cca 100 kg. They were slaughtered according to normal procedure. In these three muscles measurements were carried out for T_i, pH_i and $colour_i$ (45 min post mortem) and pH_u and $colour_u$ (24 hours post mortem). The content of total pigments (TP) as well as the WHC was determined only for a smaller number of these muscles (n 32; n 40), 24 hours post mortem. At the same time squared pieces were cut from these muscles, weighing 150 ± 5 g, cooked in plastic waterproof bags at 90°C for 60 min. Cooking loss was determined on these pieces (n 32) as well as tenderness by Warner-Brathler Shear press (n 28) and tenderness and juiciness (n 20) sensorially.
Temperature was measured by Gulton Tastotherm P200 thermometer, pH by contact potentiometer Gronert TM5, and colour by Göfo photometer. TP content was determined by Möhler's mo-

dification of Hornsey method (1958), WHC by compression, according to the method of Grau and Hamm (1953), while tenderness by Warner-Bratzler Shear press with the samples of 1/2 in in diameter.

Tenderness and juiciness of cooked muscles were determined according to the scale from 1 to 9 (1 - extremely tough, or juicy; 7 - optimal; 9 - extremely tender, or juicy).

Results and Discussion

From the results given in Table 1 it is obvious that the greatest temperature measured 45 min post mortem was registered for muscle BF and the smallest for RF. The greatest individually measured temperature was established for BF, too, amounting 42°C. Temperature differences were significant between BF, SM and RF muscles ($P < .01$) while less significant between BF and SM ($P < .05$) (Table 2).

Mean values for pH_i and pH_u were mainly uniform, i.e. without significant differences. However, small individual values were also registered ($pH_i \leq 5,9$), and the smallest pH 5.0 was registered for muscle BF.

Measurements of $colour_i$ have proved that the lightest coloured muscle was BF and the darkest SM, as well as that the difference in colour for these two muscles is significant ($P < .01$). However, 24 hour post mortem the darkest colour was measured for RF muscle, being markedly darker than the colour of BF and SM ($P < .01$). On the contrary, colour differences between SM and BF were insignificant. TP content is also the greatest for muscle RF being markedly greater than in SM ($P < .01$), but not so in the comparison with BF. Differences in TP content between SM and BF muscles are less significant ($P < .05$). From these results coincidence between colour and TP content is not seen. Namely, BF muscle was the lightest if measured 45 min or 24 hours post mortem, but has no smallest TP content. TP content of this muscle is markedly greater than for SM ($P < .05$) although it was proved that SM muscle was significantly darker 45 min post mortem. This finding leads to the conclusion that TP content in the muscle, although the most important, is not the only factor effecting colour. Therefore, the finding that BF muscle is of the lightest colour is, probably, influenced muscle contains the greatest amounts of fat and connective tissue (Rahelić and Rede, 1969; Topel et al., 1966).

These positively expressed traits are probably under no influence of pH, as pH for the investigated muscles do not markedly differ. Rahelić et al. (1978) haven't proved any expressed correlation between pH and WHC, tenderness and juiciness. The same authors have established that there is no such correlation between the colour and these traits of muscles. Reason for the fact that muscle RF is of the best and BF of the smallest tenderness and juicness should be searched in muscle structure and the relation of connective and muscle tissue in the mentioned muscles. Namely, BF muscle contains markedly more connective tissue than RF (Rahelić and Rede, 1969), i.e. more than SM (Rejt et al., 1978), whereas it could be considered that the content of connnective tissue represent the factor effecting tenderness and juiciness. Fiber diameter has no more significant influence on tenderness and juidness as the investigations of these three muscles have proved that the fibers of RF muscle of the smallest diameter (71 nm), but the greatest for SM (78) (unpublished data), which is the toughest.

Measurements of WHC for the mentioned muscles by comparison have indicated that this characteristic is mostly expressed in muscle BF as well as that this difference is more significant, between RF and BF ($P < .01$), and less significant between RF and SM ($P < .05$). From the data reviewed in Table 1 it is seen that muscle RF has released the least quantities of water in the course of cooking, but the difference between the amount of water released by this muscle and released by BF and SM, is not significant. Explanation for no expressed statistically significant differences between the amount of water released by cooking of

Table 1. Some characteristic of the three greatest raw and cooked muscles of pig ham

Characteristics	Musculus semimembranosus		Musculus biceps femoris		Musculus rectus femoris	
	$\bar{x}$	min / max	$\bar{x}$	min / max	$\bar{x}$	min / max
T_i	39,547	37,0 / 41,5	39,774	37,0 / 42,0	38,929	33,0 / 41,0
pH_i	6,356	5,4 / 7,0	6,384	5,0 / 7,1	6,353	5,3 / 7,2
pH_u	5,883	5,2 / 7,0	5,855	5,1 / 6,9	5,895	5,0 / 7,0
$Colour_i$	76,872	68,0 / 84,0	75,659	68,0 / 82,0	76,216	67,0 / 83,0
$Colour_u$	71,025	50,0 / 84,0	70,156	57,0 / 82,0	72,900	64,0 / 82,0
Total pigments (ppm)	57,801	30,60 / 83,64	66,429	35,96 / 93,16	71,226	44,20 / 107,44
WHC (cm^2)	9,697	7,95 / 11,55	9,868	7,35 / 12,05	8,858	2,80 / 12,75
Cookingloss (%)	37,531	24,33 / 42,88	38,874	27,72 / 45,31	36,188	24,39 / 42,91
Tenderness (lb)	13,837	7,21 / 22,18	14,742	4,61 / 27,36	7,231	3,03 / 13,16
Tenderness, sensorially	6,050	5,0 / 8,0	5,300	3,0 / 7,0	7,399	6,0 / 9,0
Juiciness, sensorially	5,800	5,0 / 7,0	5,550	3,0 / 8,0	6,335	4,0 / 8,0

the investigated muscles could be find in the fact that the differences between the amount of released water of the samples of the same muscle were great, for all three investigated muscles.

Results obtained by the instrumental investigations of tenderness as well as the tenderness and juiciness investigated sensorially, indicate that muscle RF is the most tender and most juicy one. It is markedly more tender than SM and BF ($P < .01$) according to the findings obtained instrumentally and by sensorial evaluations. However, differences in tenderness between SM and BF are less expressed, and only those proved by sensorial evaluations were significant ($P < .05$).

Table 2. Significance of differences for the investigated characteristics between three ham muscles

Characteristics	Muscles		
	SM/BF	SM/RF	BF/RF
T_i	x	xx	xx
pH_i	-	-	-
pH_u	-	-	-
$Colour_i$	xx	-	-
$Colour_u$	-	xx	xx
Total pigments (ppm)	x	xx	-
WHC (cm^2)	-	x	xx
Cookingloss (%)	-	-	-
Tenderness (lb)	-	xx	xx
Tenderness, sensorially	x	xx	xx
Juiciness, sensorially	-	-	-

x $P < 0,05$

xx $P < 0,01$

Conclusion

According to the findings obtained by these investigations it is possible to conclude that M. rectus femoris (RF) expresses the best, and M. biceps femoris (BF) the smallest WHC, tenderness and juicness, and that the differences in WHC and tenderness are statistically significant.

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