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Evalution of Meat From the Standpoint of Nutritive Value of Proteins.

Introduction.

Although it is generally known that the composition of meat changes according to the anatomical location and the physiological function of individual muscles, the nutritive value of meat proteins is cited in the literature by one value, often without a reference which muscle is the subject under discussion. Mitchell and Carman (1) introduce the biological value 64 and 69 for veal and beef (without further specification), resp. For beef round, however, Mitchell et al. (2) found the biological value 74,8. Miller and Bender (3) studying a determination of Net Utilization of proteins by a shortened method introduce NPU 71,5 for a beef muscle without a nearer indication. This inaccuracy can be found as well in tables FAO/WHO (4) where NPU 80 and chemical score 80 are cited for beef muscle without a detailed specification.

The nutritive value of proteins depends to a high degree on their amino acid composition. The fact that the amino acid composition changes in various kinds of muscle, is not respected. As the proteins of the connective tissue are relatively poor in essential amino acids in comparison with other muscle proteins (5), the nutritive value of meat proteins changes according to the content of the connective tissue.

There exists a relationship between the content of hydroxyproline and the content of individual available essential amino acids in proteins of veal, beef and pork; it is expressed by equations of regression straight lines (6). More detailed study showed that this relationship is valid also for other tissues and organs of slaughter animals (with the exception of brain) (7). Equations of regressive straight lines from 44 samples of different tissues and organs of calves, cattle and pigs were calculated. The samples represent always material from at least 7 various animals. From the equation of the regressive straight line for methionine

$$Y = 2.203 - 1.536\ x$$

(Y = methionine, g/16 g N; x = hydroxyproline, log. g/16 g N) and from the equation of the regressive straight line for the total of available essential amino acids

$$Y = 36.588 - 14.441\ x$$

(Y = total available essential amino acids, g/16 g N;
x = hydroxyproline, log. g/16 g N).

Chemical Score according to methionine as the main limiting amino acid was calculated. A relationship between the content of hydroxyproline and Chemical Score (7) is graphically illustrated in Fig. 1. It may be supposed that this relationship is valid for all kinds of meat of slaughter animals without regard to age, or sex.

The dependence between hydroxyproline and Chemical Score enables to determine Chemical Score of proteins on the basis of nitrogen and hydroxyproline analysis in each kind of meat.

The purpose of this paper is to demonstrate differences of the nutritive value of proteins in particular cuts of beef and pork.

Methodics.

For the study of nutritive value of beef proteins the meat from 3 animals was used. Pork was also obtained from 3 animals. More detailed characterization of these animals and yield is given in Table 1.

From cattle there was for cutting used one forequarter without a spinal cord, separated by a cut which is upright towards spine behind the eight rib, and one hindquarter without a spinal cord, including five ribs, without kidneys, kidney and pelvic suet. In addition to it head and tail were used.

From pigs the whole side of carcass after croupon separation including head, flare fat, trotters and tail was cut. Kidneys were removed. The cutting of meat was carried out in the way used in Czechoslovakia. For better information individual cuts are illustrated in Fig. 2.

From each part of the meat cuts a collagenous and fatty cut-out were separated, This cut-out was pooled, blended and taken as an independent component.

Each part of the meat cuts was after weighing finely ground and after blending a sample for analysis was separated. In each sample analysis of dry matter was carried out by drying of a weighed amount of sample at 110° C to a constant weight. Determination of fats was made by extraction of dry matter with ether in Soxhlet extractor. Proteins were calculated from the differences between the content of dry matter and fats, after substraction 1 % or 0,8 % for ash at beef or pork, resp.

A part of each sample was dehydrated and defatted by multiple extraction in ethyl alcohol, ethyl alcohol-ether and ether at the room temperature. The samples after removing solvents by drying the former in the air at the room temperature, were again finely ground and used for nitrogen and hydroxyproline analysis. Nitrogen was determined by semimicro-Kjeldahl method (8). Hydroxyproline was determined after hydrolysis in sealed tubes in 6 N HCl at 110°C for 24 hours, according to Serafini-Cessi and Cessi (9). Chemical score was calculated from nitrogen and hydroxyproline analyses according to Dvořák and Vognarová (7). The protein values of meat were measured by multiplying Chemical Scores x 10^{-2} by the amounts of proteins which it include. So a protein which can be indentified with the reference protein FAO (4), ("full-value protein") was obtained.

Results.

Analytical data obtained by cutting of particular parts of beef and pork are given in Tables 2 and 3, resp. Chemical Score was calculated from the content of hydroxyproline and nitrogen. The amount of proteins, indirectly obtained, served for the recounting to full-value proteins, corresponding to the reference protein of FAO from the nutritive point of view.

It is evident from individual columns in the Tables that values of hydroxyproline as well as Chemical Score agree well within individual cuts of meat, always obtained from 3 animals. For proteins and full-value proteins there is greater variability of individual values, probably for that reason that it was not possible to eliminate the differences in treatment of particular cuts of meat. Nevertheless, in spite of these differences, it is possible to express the full-value proteins by the average value for particular groups of meat cuts.

From Tables it is evident that organoleptically most valuable meats have high Chemical Scores which decrease with the impairing value of meat. The comparison is more objective in Fig. 3 and 4. The content of full-value proteins has a similar trend but it is influenced by a different content of total proteins and fats. This is evident in pork especially.

Discussion.

The results indicate that nutritive values of meat proteins which are expressed as Chemical Scores, differ one from another according to the localization of the used cut of meat and depend above all on the content of the connective tissue. The best cuts of meat achieve the maximum Chemical Score which is for animal tissue attainable at all. Namely, at the amount of hydroxyproline which is smaller than 0,955 g/16 g N, phenylalanine instead of methionine has become a limiting amino acid in proteins. Then Chemical Score decreases from maximal value 82,5 by several units (7).

The knowledge of Chemical Score permits to measure the nutritive value of meat proteins. For nutritive purposes this value alone is interesting only academically. Chemical Score can be held as identical with NPU standardized. For practical nutritive evaluation NPU operative can be calculated from it at a known content of proteins, serving for the calculation of Net Dietary-protein Calories per cent (NDp-Cals %) (12, 13). In that sense the calculation for meat alone is not possible because it is a part of human nourishment, the other components of which decide on the nutritive value of meat. For this reason meat was evaluated in this paper only by changing the values into proteins corresponding with respect to their quality to the reference protein, i.e. to the protein of the whole egg of hen (4). The full-value proteins, expressed in grams per kilogram of meat, include then simultaneously the nutritive quality of proteins and their amount.

The comparison of Chemical Score with subjectively measured quality of meat, shows that Chemical Score is a good objective criterion of meat quality. This criterion could be used for meat products, too, The authors determinated formerly the nutritive value of proteins in meat products on the basis of available essential amino acids analysis. Diferences between the values experimentally determined and the values calculated on the basis of raw material which is prescribed for a given product by standard, were obtained (14).

As it is not possible to suppose a significant impairment of the nutritive value of proteins in meat products, a less valuable raw material used into meat products than the standards allow, can be held as a cause of these differences. It may be supposed that measuring of Chemical Score and full-value proteins in meat products will serve for checking the lowest permissible quality.

For obtaining Chemical Score the analysis of hydroxyproline and nitrogen is sufficient. The evaluation in this paper was carried out, however, only on dehydrated and defatted samples which is not convenient for continual and quick work. Analysis of hydroxyproline is also time consuming. The authors hope that they will outdo these difficulties in future.

In this paper there are tendenciously not discussed differences in chemical criterion caused by the use of meat from animals of various age and sex for the evaluation of beef and by the use of pigs of different weight categories for the evaluation of pork. The differences concern the content of total proteins and fats.

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Table 1. Characteristics and yield of analyzed cattle and pigs.

Cattle:	Cow	Bullock	Heifer
Breed:	Red-mottled cattle		
Age (years)	5-6	2 1/4	2
Grade:	II	I	I
Live Weight, kg	430	410	385
Obtained meat, kg	174,4	196,0	154,0
Obtained bones, kg	36,0	39,0	33,0
Head without tongue, kg	10,5	15,0	14,0
Analysed forequarter, kg	47,7	53,5	40,2
Analysed hindquarter, kg	59,4	64,5	54,2

Pigs - Breed	Large White Breed		
Live Weight, kg	82	105	119
Weight of a side, kg	32,2	41,7	46,9
Obtained yield before treatment, kg:			
Gammon with trotter and tail	8,40	9,90	11,25
Shoulder with trotter	4,20	5,10	6,30
Head (a half)	2,09	2,17	2,70
Jowl	1,44	2,53	2,11
Neck	2,44	2,59	3,35
Fore Loin	2,14	3,38	3,70
Hind Loin	1,30	1,28	1,97
Belly	4,90	6,80	7,60
Flare Fat	0,87	1,61	1,35
Back Fat	4,44	6,30	6,55

Table 2. <u>Nutritive value of particular cuts of beef.</u>

(No. 1 - cow, No. 2 - bullock, No. 3 - heifer)

N a m e	Weight kg	Hydroxyproline g/16g N	Chemical score	Proteins g/kg	Full-value proteins g/kg	Fats g/kg
Cutt-off meat from head	2,46	6,69	52,7	199,1	104,9	155,7
	3,43	6,71	52,5	186,2	97,8	124,8
	4,34	6,65	52,8	165,3	87,3	218,2
ø			52,7		99,0	
Cheek meat	2,04	5,07	58,8	213,0	125,2	47,2
	3,02	5,01	59,0	218,6	129,0	20,2
	2,20	4,85	59,7	206,8	123,5	55,7
ø			59,2		125,9	
Muzzle	0,80	10,72	41,5	206,2	85,6	69,8
	0,80	10,12	42,7	237,2	101,3	13,0
	0,55	8,15	48,2	191,0	92,1	56,3
ø			44,1		93,0	
Neck (1)	7,26	4,03	63,0	203,5	128,2	40,8
	8,50	3,32	66,0	207,0	136,6	34,5
	3,39	3,48	65,3	205,2	134,0	43,5
ø			64,8		132,9	
Back Ribs (2)	5,10	1,83	74,5	209,4	156,0	37,1
	5,70	1,82	74,5	194,6	145,0	58,4
	4,02	2,37	71,0	189,8	134,8	107,2
ø			73,3		148,6	
Rib Roast (3)	2,49	2,12	72,6	210,2	152,6	60,3
	2,80	1,90	74,0	196,1	145,1	74,7
	2,30	1,75	75,0	190,7	143,0	121,3
ø			73,9		146,9	
Top Rib (4)	2,05	2,63	69,5	213,3	148,2	48,7
	2,16	2,92	68,5	200,8	137,5	114,5
	1,82	2,92	71,8	198,7	142,7	129,1
ø			69,9		142,8	
Thin Rib (5)	2,32	2,63	69,5	213,3	148,2	44,2
	2,43	2,82	68,5	200,8	137,5	67,7
	1,98	2,25	71,8	198,7	142,7	137,3
ø			69,9		142,8	

Cled (Vein) (6)	2,41	2,36	71,0	194,6	138,2	68,7
	3,40	2,83	65,0	185,0	120,3	110,5
	1,98	2,46	70,5	194,4	137,1	109,6
ø			68,8		131,9	
Brisket (7)	2,33	2,71	69,2	214,5	148,4	72,5
	2,72	2,23	72,0	189,7	136,6	111,8
	1,91	2,08	73,0	200,2	146,1	114,3
ø			71,4		143,7	
Sheulder (8)	4,75	1,76	74,5	222,1	165,5	28,4
	5,96	1,90	74,0	202,7	150,0	52,3
	4,17	1,54	78,0	208,3	162,5	62,2
ø			75,5		159,3	
(9)	1,57	3,61	54,5	213,2	116,2	25,6
	1,48	3,50	65,3	215,6	140,8	23,4
	1,13	2,94	63,3	210,2	133,1	62,6
ø			61,0		130,0	
(10)	0,33	3,84	64,8	208,4	135,0	25,6
	0,54	4,07	62,8	216,3	135,8	26,2
	0,41	1,81	74,7	210,8	157,5	36,7
ø			67,4		142,8	
(11)	1,51	2,14	72,5	207,0	150,1	34,2
	1,41	2,35	71,2	203,3	144,7	35,7
	1,11	2,52	70,2	213,0	149,5	52,3
ø			71,3		148,1	
(12)	2,43	3,95	63,5	213,0	135,3	38,3
	2,79	3,65	64,7	205,0	132,6	46,0
	1,32	2,74	69,2	203,9	141,1	61,6
ø			65,8		136,3	
Fore Shin (13)	1,51	3,58	65,0	214,6	139,5	22,4
	1,93	4,64	60,5	218,5	132,2	27,5
	1,46	3,68	64,5	221,9	143,1	41,1
ø			63,3		138,3	
Sirloin (14)	6,12	2,06	73,0	220,5	161,0	47,5
	7,12	2,56	70,0	210,7	147,5	49,8
	5,59	2,90	68,2	210,1	143,3	89,2
ø			70,4		150,6	
Tenderloin	2,44	1,00	82,0	219,3	179,8	56,7
	2,54	1,45	77,7	199,4	154,9	53,6
	1,77	1,14	80,4	201,7	162,2	72,3
ø			80,0		165,6	
Thin Flank (15)	4,31	2,48	70,4	217,4	153,0	68,1
	4,52	3,02	67,5	192,5	129,9	124,8
	3,06	2,66	69,5	183,7	127,7	195,3
ø			69,1		136,9	
Thin Flank (16)	3,56	3,41	85,7	224,2	147,3	50,6
	4,94	3,05	67,5	206,9	139,7	53,2
	3,57	3,24	66,5	209,5	139,3	104,0
ø			66,6		142,1	

Tail	0,76	5,57	56,8	226,7	128,8	88,3
	1,12	5,04	58,9	234,7	138,2	75,3
	0,68	5,17	58,3	215,5	125,6	180,5
ø			58,0		130,9	
Total cut-out	7,09	7,27	50,8	164,8	83,7	289,2
	7,60	8,63	45,2	158,0	71,4	355,0
	10,04	7,36	50,7	105,0	53,2	516,0
ø			48,9		69,4	
Topside (17)	7,98	1,76	75,0	239,2	179,4	26,8
	7,98	0,90	83,2	209,2	174,1	18,3
	6,21	1,55	77,0	221,2	170,3	34,8
ø			78,4		174,6	
Silverside (18)	8,63	1,61	76,3	221,5	169,0	19,8
	9,51	1,37	78,4	208,5	163,5	23,2
	5,68	1,47	77,5	218,1	169,0	32,9
ø			77,4		167,2	
Part of hough (between 17, 18, 21)	1,93	2,25	72,0	227,7	163,9	22,4
	2,17	3,30	66,3	213,1	141,3	19,9
	1,30	3,26	66,4	223,4	148,3	38,6
ø			68,2		151,2	
Rump (19)	3,82	1,12	80,7	218,1	176,0	22,9
	4,04	1,87	74,3	207,7	154,3	36,3
	3,60	1,64	76,0	211,8	161,0	73,7
ø			77,0		163,8	
Thick Flank (20)	5,88	2,14	72,5	207,9	150,7	29,6
	6,23	1,72	75,3	205,0	154,4	28,0
	4,94	1,40	78,2	217,8	170,3	34,7
ø			75,3		158,5	
Hind Shin (21)	2,05	3,28	66,4	213,7	141,9	42,3
	1,96	3,42	65,7	207,3	136,2	26,2
	1,46	3,12	67,3	212,2	142,8	64,8
ø			66,5		140,3	
Altogether (without head and part of hough)	88,70		70,3	212,6	149,4	59,6
	99,38		70,3	200,7	141,1	74,0
	73,60		70,9	194,8	138,2	139,4

Table 3. <u>Nutritive value of particular cuts of pork.</u>

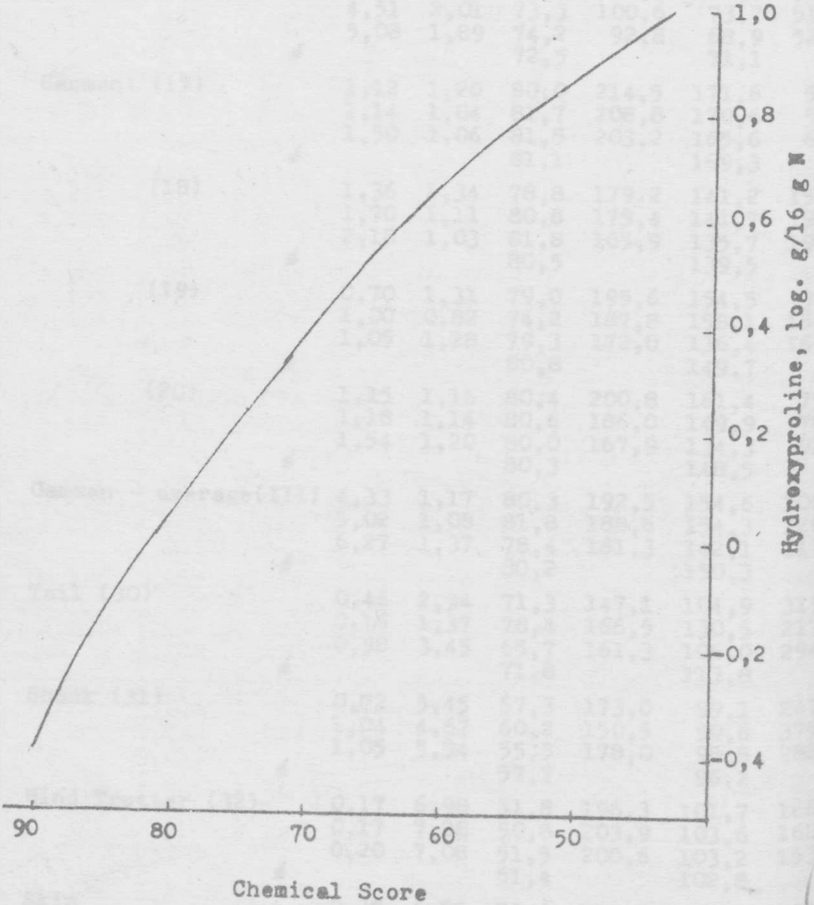
(No. 1 - side of a pig, Live Weight - 82 kg, No. 2 - 105 kg, No. 3 - 119 kg).

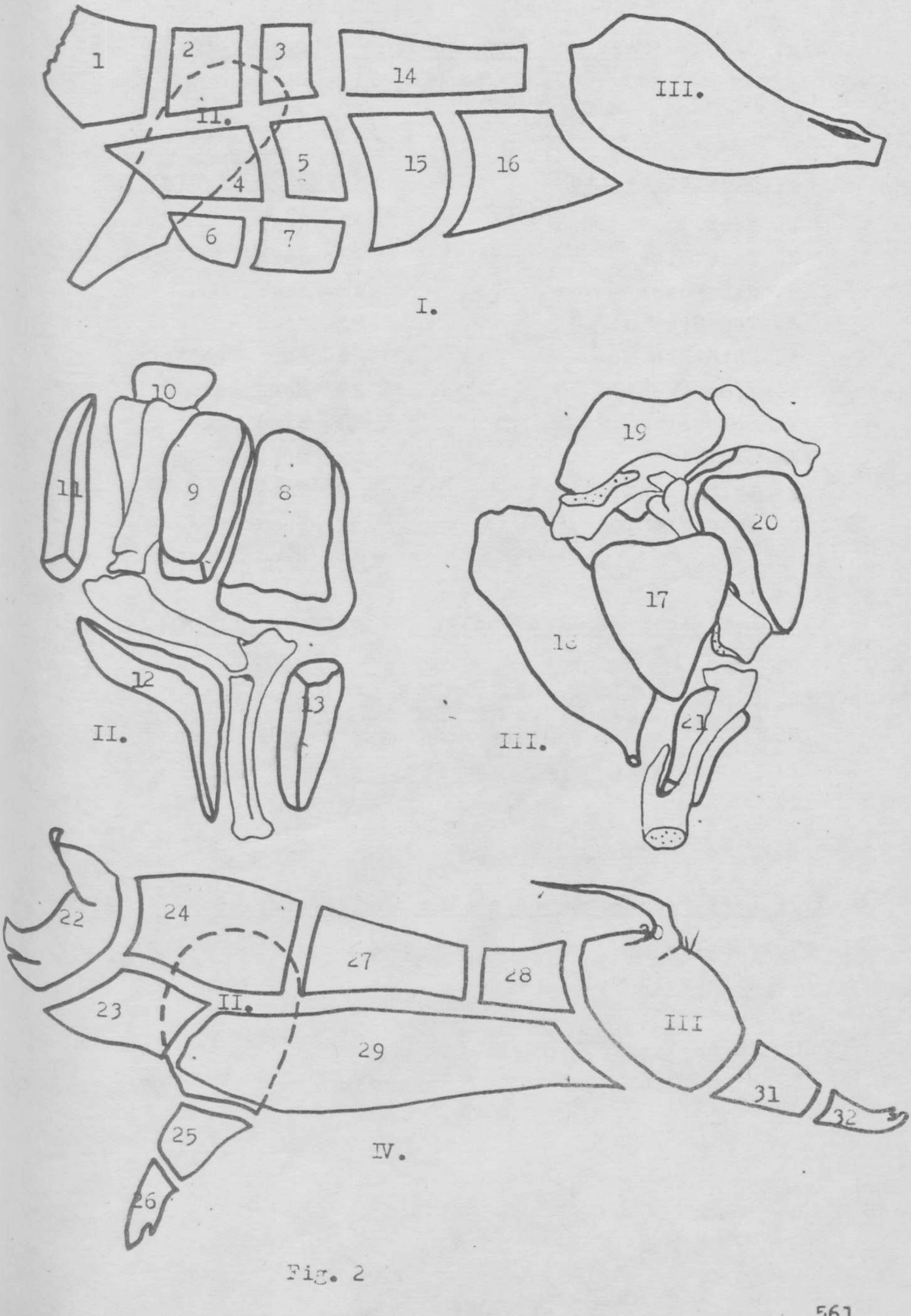
Name		Weight	Hydroxyproline g/16g N	Chemical score	Proteins g/kg	Full-value proteins g/kg	Fats g/kg
Head (22)		1,22	6,15	54,6	145,2	79,3	366,5
		1,30	6,23	54,5	152,8	83,3	361,5
		1,47	5,76	56,0	146,6	82,1	370,8
	ø			55,0		81,6	
Jowl (23)		0,67	6,02	55,0	110,2	60,6	403,1
		1,00	6,42	53,8	71,1	38,3	682,0
		0,96	6,29	54,1	76,9	41,6	622,0
	ø			54,3		46,8	
Shoulder (II)		2,87	1,93	73,9	156,6	115,7	222,5
		2,90	1,67	75,8	157,6	119,5	261,0
		4,07	1,86	74,5	157,3	117,2	213,0
	ø			74,7		117,5	
Neck (24)		2,12	1,68	75,7	125,9	95,3	206,8
		2,28	1,67	75,8	137,7	104,4	319,0
		2,93	1,76	75,0	142,5	106,9	277,8
	ø			75,5		102,2	
Hock (25)		0,40	4,75	60,0	173,4	104,0	216,8
		0,65	5,16	58,2	173,9	101,2	239,8
		0,79	5,09	58,8	169,5	99,7	236,8
	ø			59,0		101,6	
Fore Trotter (26)		0,13	7,42	50,5	206,7	104,4	170,8
		0,15	7,26	50,9	199,5	101,5	181,2
		0,18	6,46	53,5	203,2	109,0	172,8
	ø			51,6		105,0	
Back Fat		2,93	6,55	53,2	10,4	5,6	916,9
		4,56	6,73	52,8	7,8	4,0	920,7
		5,15	6,64	53,0	17,5	9,3	896,1
	ø			53,0		6,3	
Flere Fat		0,87	4,97	59,1	10,7	6,3	967,4
		1,61	4,68	60,0	15,3	9,2	909,3
		1,35	4,38	61,5	11,5	7,1	920,3
	ø			60,2		7,5	

Fore Loin (27)	1,78	1,58	76,6	151,4	116,0	300,3
	2,84	1,24	79,5	163,3	129,8	290,9
	3,01	1,84	74,5	141,9	105,7	318,3
ø			76,9		117,2	
Hind Loin (28)	1,09	1,30	78,7	179,8	141,5	187,9
	1,11	1,23	79,7	159,4	127,0	227,5
	1,70	1,19	80,0	162,7	130,2	239,5
ø			79,5		132,9	
Belly (29)	3,20	2,54	70,0	100,1	77,7	525,0
	4,51	2,01	73,3	100,6	73,7	516,0
	5,08	1,89	74,2	92,8	68,9	520,7
ø			72,5		71,1	
Gammon: (17)	1,12	1,20	80,0	214,5	171,6	52,4
	1,14	1,04	81,7	208,8	170,6	58,9
	1,50	1,06	81,5	203,2	165,6	61,8
ø			81,1		169,3	
(18)	1,36	1,34	78,8	179,2	141,2	158,5
	1,70	1,11	80,8	175,4	141,7	195,8
	2,18	1,03	81,8	165,9	135,7	198,3
ø			80,5		139,5	
(19)	0,70	1,31	79,0	195,6	154,5	95,3
	1,00	0,82	74,2	187,8	158,1	154,9
	1,05	1,28	79,3	172,0	136,4	160,2
ø			80,8		149,7	
(20)	1,15	1,16	80,4	200,8	161,4	75,7
	1,18	1,14	80,6	186,0	149,9	78,7
	1,54	1,20	80,0	167,9	134,3	92,3
ø			80,3		148,5	
Gammon - average(III)	4,33	1,17	80,3	192,5	154,6	106,3
	5,02	1,08	81,8	188,6	154,3	126,3
	6,27	1,37	78,4	181,3	142,1	117,8
ø			80,2		150,3	
Tail (30)	0,46	2,34	71,3	147,1	104,9	319,3
	0,16	1,37	78,4	166,5	130,5	217,9
	0,98	3,45	65,7	161,3	106,0	294,6
ø			71,8		113,8	
Shank (31)	0,72	5,45	57,3	173,0	99,1	247,0
	1,04	4,67	60,2	150,5	90,6	375,3
	1,05	5,94	55,5	178,0	98,8	288,8
ø			57,7		96,2	
Hind Trotter (32)	0,17	6,98	51,8	196,3	101,7	166,5
	0,17	7,28	50,8	203,9	103,6	162,4
	0,20	7,08	51,5	200,6	103,2	153,5
ø			51,4		102,8	
Skin	0,38	6,52	53,3	151,0	80,5	128,0
	0,54	5,23	58,3	144,1	84,1	99,1
	0,66	5,91	55,6	72,7	40,4	219,0
ø			55,7		68,3	

Celagenous and fatty cut-out		4,99	3,76	64,3	91,7	59,0	562,0
		7,49	3,47	65,5	81,3	53,2	596,5
		5,99	3,99	63,0	80,3	50,6	586,0
	ø			64,3		54,3	
Total average		28,33		71,3	122,1	87,1	406,0
		37,33		72,5	112,2	81,4	468,7
		41,84		71,0	115,9	82,3	428,2
	ø			71,6		83,6	

Fig. 1. Relationship between hydroxyproline and Chemical Score (methionine) in the tissues of slaughter animals (7)




1
2
3
14
III.
II.
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16
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II.
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III
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25
26
IV.

Fig. 2

Fig. 2. **Beef and pork cutting (fig. according to (10, 11)**

I. Side of cattle

1. Neck
2. Back Ribs
3. Rib Roast
4. Top Rib
5. Thin Rib
6. Clod (Vein)
7. Brisket

14, Sirloin
15, Thin Flank
16. Thin Flank

IV. Side of pig

22. Head
23. Jewl
24. Neck
25. Hock
26. Fore Trotter
27. Fore Loin
28. Hind Loin
29. Belly
30. Tail
31. Shank
32. Hind Trotter

II. Left shoulder looking at the outside surface

8.
9.
10.
11.
12.
13,

} cuts of shoulder* according to the Czechoslovak cutting

III. Left round looking at the inside surface

17. Topside
18. Silverside
19. Rump
20. Thick Flank
21. Hind Shin

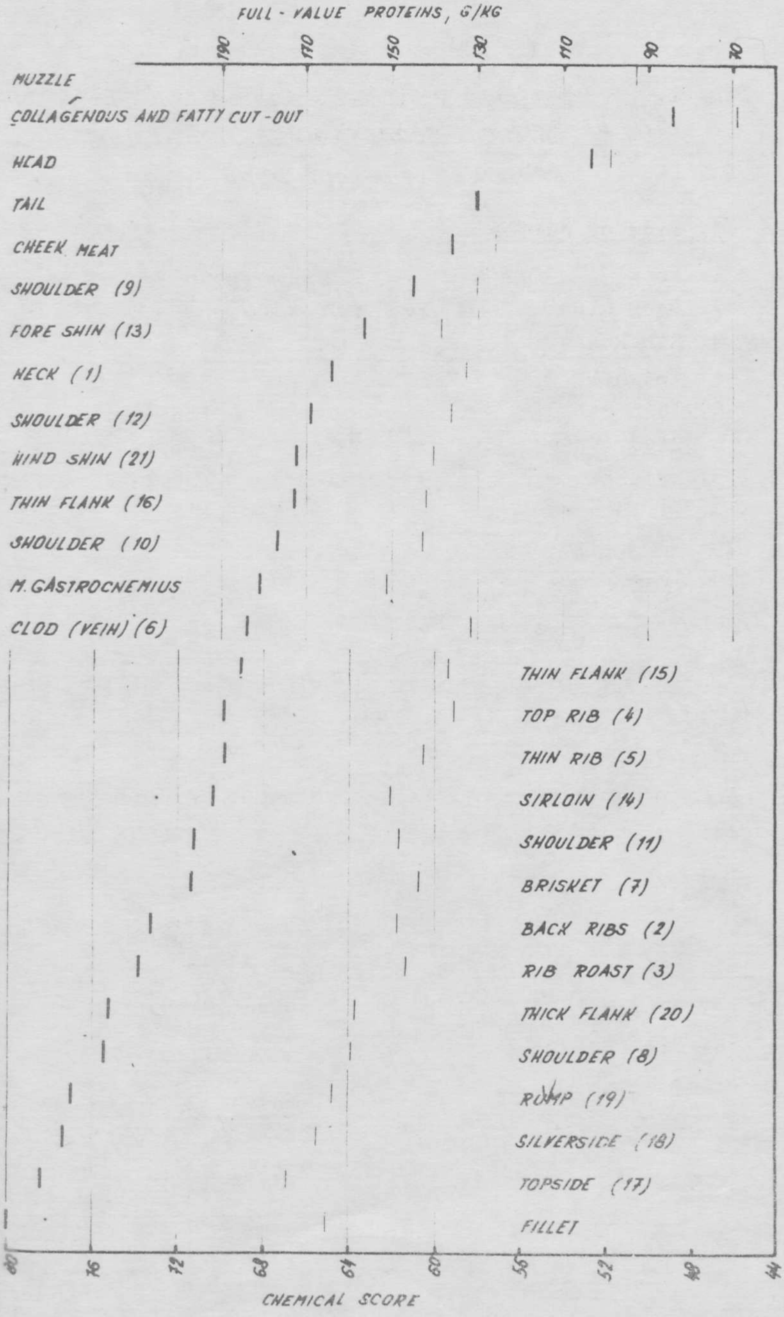

FIG. 3. CHEMICAL SCORE (|) AND FULL - VALUE PROTEINS (|) IN CUT BEEF

FIG. 4. CHEMICAL SCORE (|) AND FULL - VALUE PROTEINS (|) IN CUT PORK