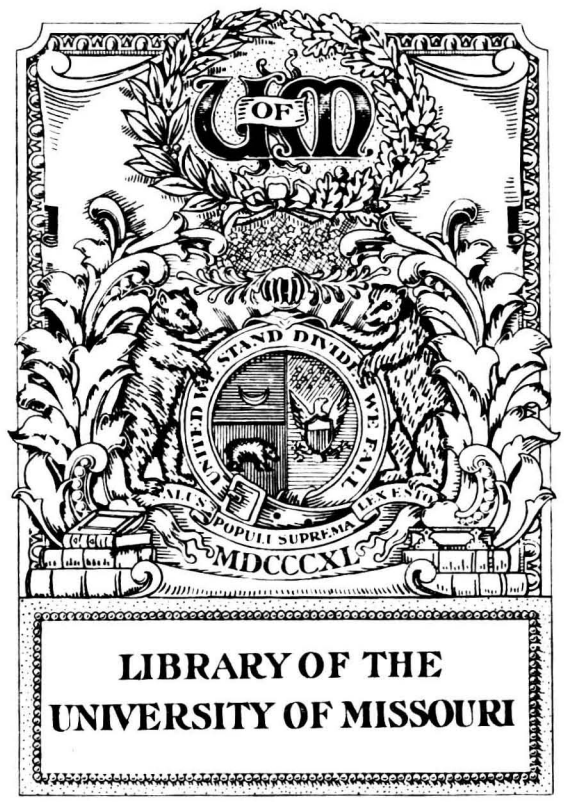
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HORSE FLESH AND ITS DIGESTIBILITY

by

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HORSE FLESH AND ITS DIGESTIBILITY

PART I

REVIEW OF LITERATURE

Historical outline of use of horse flesh. The use of horse flesh as a human food is a custom as old as that of using the flesh of any other food producing animal. Proof of its use by the cave men has been unearthed in Northern Europe by the archaeologists.[1] Judging from the quantity of remains found associated with those of men of that time, wild horses were very abundant in the prehistoric Neolithic, or polished stone period, and the chase of the animal must have been one of man's chief occupations, providing him with one of his most important food supplies.

The horse was an idol[2] among the early tribes of Scandinavia and Germany. The Germans sacrificed and ate horses at feasts in honor of Odin and Freya, at which feasts horse flesh was the favorite dish. In order to remove all signs of pagan worship and sacrifice, Pope Gregory III and his successor, Zacharias I, sent edicts to St. Boniface, the Christian Apostle in the Germanic Countries, prohibiting the use of horse flesh, and declaring that horse flesh and all those eating and dealing in it unclean, and that dealings with them were to be avoided. These same edicts[3] were also issued to the people of Iceland where hippophagy was also very popular. But it was not until about the year 1000 A. D., three centuries

later, that the European people openly discontinued the custom.

Among the nomadic peoples,[2,3] for example, the Tarteris, Kirghis, and Kalmucks, to whom the Pope's decree did not go, and did not apply, hippophagy has continued unchecked to the present day. These mentioned peoples ate the flesh fresh, salted, and smoked, and seemed to have a passionate desire for it.

That horse flesh was eaten at the time of Moses is evident from the prohibitive clauses in the Mosaic Law against its use as food. The early Greek writers and Philosophers mention the eating of horseflesh as an early custom that existed from the extreme East to the Ural mountains and that this custom existed among the early Persians, Greeks and Romans. It seems that throughout Asia the eating of horseflesh was customary. According to Ostertag[4] the Chinese have used horseflesh for ages, and have developed a special breed of ''Fat'' horse, that was characterized by its fine bone structure, fattening powers, and savory meat. The animal has a large feeding capacity, and at about two years is quickly and readily fattened on a ration of rice and corn.

''Philips writes of the use of horses, asses, and mules by the Moors in Tunis, Algiers, and also of the presence of a species of a small horse that was raised solely for food purposes by negroes in Juida, Africa. In Marmol, Africa, wild horses were used for food by the

natives. In South America, French and English explorers repeatedly mention the use of the flesh of wild and domesticated horses for food purposes, as a custom in the various countries. Sir Francis B. Head stated that the Pampas ate the flesh of mares, which they never rode. Delvaille refers to the natives of Bolivia as preferring horsemeat, and other state that hippophagy was in vogue in Chili and among the Patagonians.''[3]

Of civilized Europe[4], Denmark was the first to return to the custom. During the siege of Copenhagen permission for the practice was given, and in the following year (1808) the practice was legalized throughout the country. During the famine years (1816-17) especially in Germany and Switzerland meat from fattened horses was consumed.

Dr. Esser[2] attributes the general introduction in Germany to the propaganda of a humane organization, which had as its aim the consumption of horses as food in order to save the old and crippled ones from merciless masters. The idea was first realized in the famine year 1847. Horse flesh, prepared in various ways, was served to very important and influential men at public banquets. Spinola, the Professor of Veterinary Science, and Blume, the country opera singer, established the first horse-slaughter pen in Berlin and turned it over to reliable parties. In 1855, Germany permitted the sale and use of horse flesh; Munich[3] had already done so in 1840. The practice was legalized in Vienna[3] in 1854. On July 9, 1866, due to the influence of Decroix, St. Hilaire, and others, France[4]

authorized the sale and use of horse flesh. At the present time horse-meat is sold publically in all European countries with various degrees of popularity.

It was not until 1889 that Great Britain[3] passed a regulation permitting the sale of horse-meat. Statistics as to the extent of its use are not available. In the winter of 1916-17[3] the ''Butchers Advocate'' of London writes as follows: ''Shops for the sale of horse flesh are being introduced into every large town. The high price of beef, mutton and pork is giving horse flesh an opportunity to acquire favor, and if present cost of living continues after the war, horse flesh may become a permanent article of food.''

During the Siege of Paris[4] 65000 horses are reported to have been consumed as food. In fact horse flesh was used continuously for six months, and no bad results were noted. To what extent the horse flesh was consumed and was popular in Europe during the early part of the nineteenth centruy cannot be determined, but it appears from later sale and use that the governments gradually permitted its sale and use as a necessary and protective measure.

The use of horse flesh in the United States has not gained in favor to the slightest extent even to the present day. History mentions the fact that the Confederate army besieged at Vicksburg during the Civil war were reduced in supplies till they had to use mule steak.

In 1898-1900 due to an export trade[6] there was established an inspection for horse-meat. The product was almost entirely exported. The inspection ceased in 1904 but was revived[9] July 1, 1919, when appropriation of $100,00 was made to carry it on for the fiscal year.

Consumption of Horse flesh. In European countries, through all figures available are incomplete and probably underestimated, it is seen from the statistics that the use of horseflesh as a human food has been marked by an increasing public demand. This is also borne out by the consular reports which from time to time mention the increase in the consumption of horse flesh. Ostertag[4] states that two thirds of the horse flesh used in Paris is manufactured into sausages, and also that more than 100,000 of the 600,00 families in the city use horse flesh. The 23,186 horses, 383 asses and 33 mules slaughtered in Paris in 1894[4] yielded together over eleven million pounds of meat, while those slaughtered in 1910[3] furnished twenty-nine million pounds.

The Bureau of Animal Industry Report (1905) states that there are slaughtered annually 30,500 horses in the two Municipal Abattoirs of Paris. Practically two thirds of these are consumed in the city of Paris itself. Other European cities have municipal abattoirs.

Number of Horses, Asses and Mules

Slaughtered in Paris[3]

1866 - 1910.

	Total	Horses	Asses	Mules
1866 (from July 9)	902	- - -	- -	- -
1867	2125	2069	59	24
1868	2425	2297	97	11
1870-71	65000	64362	635	3
1872	5732	5034	675	23
1875	6865	6448	394	23
1878	11319	10800	438	31
1888	13475	- - -	- -	- -
1898	21476	- - -	- -	- -
1900	25059	- - -	- -	- -
1902	31342	- - -	- -	- -
1904	44279	- - -	- -	- -
1906	58856	- - -	- -	- -
1910	60336	57734	824	223

Their slaughter of horses is as follows.[3]

Year	Cities	Number of Horses
1909	Berlin	12890
1892	Vienna	18290
1907	Milan, Italy	7132
1906	Liège, Belgium	1375

The 28th Annual Report of the Bureau of Animal Industry shows that in 1909 Germany slaughtered 152,214 horses which provided 79 million pounds of meat, about 1 1/2 pounds per capita. Also that there were 6990 dogs slaughtered for food purposes. Recent consular and Trade Reports say that the con--sumption of both horse and dog flesh has shown a decided increase.

No data on the consumption of horseflesh in Italy seems available, but it must be extensive. ''By a decree of July 24, the slaughter of horses, asses and mules, suitable for raising or for breeding is forbidden in Italy. The suitableness of an animal for raising or breeding will be determined by the communal veterinary or by an expert appointed by the mayor. The same decree prohibited the transportation of freshly slaughtered horse flesh from one commune to another.''[5]

Horses Slaughtered in German Cities. (Ostertag)

1890	Munich	1728	Horses
1885	Saxony	3313	,,
1890	Saxony	4249	,,
1896	Saxony	5091	,,
1899	Saxony	5181	,,
1895	Leipsig	961	,,
1900	Leipsig	1839	,,
1899	Dresden	1474	,,
1890-91	Prussia	52281	,,
1893-94	Prussia	63801	,,
1899	Breslau and Drusseldorf	5000	,,
1892	Vienna	1892	,,

The Municipal Abattoir in Odessa, Russia,[3] slaughters 150,000 food animals annually. Of this number 300 are horses which are slaughtered during the winter months for use by the Tartars..

Comparison of Number of Animals Slaughtered in Belgium 1905 - 1909. Average. (Price)[3]

Horses	38,200
Cattle	438,900
Calves	350,500
Lambs and Sheep	352,400

In 1898 the Bureau of Animal Industry[6] received an appropriation for that year providing ''That live horses and the carcasses and the products thereof be entitled to the same inspection as other animals, carcasses and products thereof.'' The reports of this Bureau give the following data on the slaughter in the United States.

1899	3,332	Horses
1900	5,559	,,
1901	1,992	,,
1902	1,649	,,
1903	344	,,

Most of the horse-meat produced was exported as the figures, given below, will show. Little if any

of it was consumed in this country. It seems that the inspection was introduced solely to encourage the exportation, as the following letter from the Consular Report[7] of April, 1900, shows, ''Several years ago I called attention of Danish dealers in horse-meat to the American supply. I have now to report that the business is increasing rapidly and the meat from the United States gives satisfaction. The consumption of horsemeat in Denmark is comparatively large and Copenhagen is a distributing port for Sweden, Norway, Finland, Russia and the German Baltic.''

Horses Exported from United States.[8]

Year	No. Packages Inspected Horse-meat	Number Certificates Issued	Packages Exported	Weight Lbs.
1900	602	8	472	188,800
1901	821	9	880	249,900
1902	638	11	638	170,986
1903	70	1 shipment	70	28,000

For the present fiscal year (1919-1920) the Bureau of Animal Industry[8] has been authorized to conduct an inspection of horse meat. In answer to inquiry this Bureau gives the following information regarding the

slaughter in the United States at the present time:

Number of Establishments	City	Monthly Slaughter	Market
1	Portland, Oregon	33	
1	Milwaukee, Wisconsin	20	Largest part to Chicago Zoological Gardens.
1	Grand Island, Neb.	8	
2	St. Louis, Missouri	85	One-half to Zoological Gardens.
1	Cincinnati, Ohio	30	
1	New York City, N. Y.	68	

The Cincinnati plant is the only one that at present is operating under the Federal Meat Inspection Law for horse flesh.

In 1895 the Hamburg butchers[2] paid from 25 to 30 dollars for well fed horses and from 10 to 20 dollars for poor ones. Very few figures giving the value of the live animal and the retail price seems available, but the statistics a few years old may afford a comparison between horse and other fleshes.

Meat Prices in Göttingen 1895[2].

1 M - 25 ¢ / 100 Pf. / 1 M	Horse Meat per kilo M.	Horse Meat per kilo Pf.	Bovine Flesh per kilo M.	Bovine Flesh per kilo Pf.	Pork per kilo M.	Pork per kilo Pf.	Mutton per kilo M.	Mutton per kilo Pf.
1. Cooked	-	60	1	40	1	40	1	40
2. Fillet	1	--	2	80	2	--	1	60
3. Raw and Cooked Hams	1	20	-	--	2	40	-	--
4. Fat	1	20	1	20	1	60	-	--
5. Rib or Plate	-	60	-	--	1	40	-	--
6. Bologna Sausage	1	20	-	--	2	40	-	--
7. Ground Meat	-	80	1	60	1	60	-	--

During the recent World War when meats were scarce England[11] found it necessary to ration horsemeat along with other meat and food products. Four coupons obtained a weeks meat ration. With one coupon a person could obtain seven ounces of cooked, canned or preserved horse-meat.

Consumption per Capita of Meats.

	Germany[10] 1909 lbs.	France[10] 1909 lbs.	Belgium[3] Annual Average 1905-09 lbs.	Madgeburg[4] 1896-7 lbs.	Konigsberg[4] 1895-6 lbs.
Horseflesh	1.25	1.000	3.32	3.08	1.41
Beef	32.00	39.00	38.59	55.00	25.63
Pork	63.00	14.00	- -	55.00	51.33
Veal	6.00	8.00	6.67	8.37	6.27
Lamb and Mutton	3.00	20.00	1.63	5.50	4.84

The consular and trade telegrams of recent date throw some light on the recent consumption of horseflesh in Europe. They report as follows: The domestic supply of horseflesh (1919) meets the demand in Denmark. In Norway, where in 1918 the consumption was above normal, horseflesh has been sold at a maximum price of 2.5 kroners per kilo (about 35 cents per pound), but most of it is either made into sausages and bologna, or smoke treated. Holland, who before the war, imported large numbers of horses for slaughtering, at the present time imports none. Paris is reported to slaughter 65,000 horses annually. Belgium has long used horseflesh, and at present slaughters on an average 700 horses weekly. The meat which is all distributed thru governmental channels sells for 2.0 to

3.25 francs per kilo (18-29 cents per pound), while beef cuts average 90 cents per pound. In 1912 Belgium imported for slaughter 25571 horses, and in 1913, 24,093.

In 1910 Germany[12] slaughtered 149,048 horses, in 1911, 151,990, and in 1912, 178,961.

A factory[13] at Esbjerg, Denmark, makes from fresh horse bones, a bullion extract, bone fat, and bone meal. The bullion is mostly exported to Germany, and the fat that is used by bakers and sausage makers, sells at 2 crowns ($0.54) per kilo.

Uses of Horse Flesh and Fat. Horse flesh in parctically every country where used has more secret buyers than open admires. It is cheaper than other meats, which stimulates its use among the poorer classes. It is to be noticed that on a whole the prejudice against it has lessened, not yet disappeared, that as it becomes more popular among the poorer classes, the abhorrence for the same increases among the people of means. This is justified because the horses slaughtered are mostly old unfattened horses, and because the horse has been esteemed above all other animals, even the dog.

Villain[4] says that two thirds of all horse-meat is used in sausages. When ground up and made into sausages its presence is exceedingly hard if not impossible to detect. The fat is used for cooking and for making soap, and may be used as an adulterant in butter.

Boiled horse flesh cannot be distinguished from

boiled beef by taste or smell. If the flesh[2] is laid in vinegar and properly prepared it cannot be differentiated from venison. It is certainly as tasty as any other meat, and may have a slight sweetish taste, due to its high content of glycogen.

On cooking[2] one notices golden fat droplets in the broth.

In speaking of meat extracts Ostertag[4] says: ''With regard to horse meat, Liebig says that the meat broth from horse-meat, when steamed, forms, membranes over the surface like that of milk, which are renewed as often as removed. Moreover, the extract is thick and slimy, does not dissolve perfectly in water and always tastes of fat.''

The exclusive consumption[4] of horse meat may cause diarrhea. This was the recent experience of the beleaguered cities in China and in the Transvaal. This has also been observed in consequence of eating dog flesh. Pflüger[4] states that the diarrhea may be caused by a substance soluble in alcohol, contained in the horseflesh, which passes over into the meat broth. It consists of three-fourths lecithin and one-fourth neutral fat and cholesterin. The injurious effect may be avoided if the meat is prepared with beef or mutton tallow, or if the meat broth is poured off. Huidekoper[3] states that horse-meat should always be broiled or roasted.

Lindet[14] suggests the use of serum albumin of the

horse as an inexpensive and satisfactory substitute for eggs in cooking.

"[3] The following are the conclusions that were reached by the Italian Army Veterinarian's Costa and Mori in regard to the use of refrigerated horse-meat: 'Flesh of horses in normal physiological condition, slaughtered under suitable rest, whether skinned or quartered and left in the skin, will keep perfectly well for two months if subjected to a temperature between 1 and 4 degrees centigrade, and an air moisture of 60 to 70 degrees.

Meat cut in small pieces will not keep longer than 20 to 30 days, showing signs of decomposition in 15 days. The flesh in the skin, if withdrawn from the refrigerator every five days and left for 24 hours in ordinary temperature, keeps in good condition from 20 to 30 days, if carcasses were skinned and quartered would be but 15 to 20 days. The liver does not keep more than 8 to 10 days when it turns pitch black, becoming unsightly and a few hours after removal from cold cells decay, showing that this organ is the least resistant to chemical or bacterial change. The kidney keeps 20 days. Brain if not removed from skull keeps two months, if removed but one week at the longest. Loss in weight was from 8 to 10 per cent in 30 days.

Refrigerated horseflesh after 15 days turns dark red to black. The consistancy remains normal for a long time. Chilled horse flesh becomes tender in 10 to 45 days, the

outer surface appears brighter than the fresh horsemeat. After ten days storage in the cold room the meat cooks more rapidly than fresh meat and requires the same time as to cook unchilled beef of a 2 to 5 year old animal. The meat of tired animals was found not to cause any bad effects, but gave evidence of lack of taste.'''

Dr. Esser[2] states that in Paris in 1856 the average dressed horse carcasses weighed 190 kilos, whilst in 1881, the same weighed 225 kilos. This leads one to believe that better fleshed horses were being used for food than formerly. in 1903 the average weight of the dressed horse carcass[15] was 250 kilos. About one-third of this weight was bone and sinew which was sold at 4 francs (77.2 ¢) per 200 kilo. There remained about 167 kilos of marketable meat per horse.

Whenever horse flesh is used as an adulterant its presence is very difficult if not impossible to detect. Various methods have been offered for its detection, of which the following are the more important:

1. Appearance, color, bone, etc.,
2. Shortness of fiber observed by microscopic inspection.
3. Crystals of hemin.
4. Development of the specific animal odor on treatment with sulphuric acid.
5. The high glycogen content.
6. The biological serum test.

The first four of these have proved absolutely unreliable, while the last two have their limitations. Opinions vary with regard to the value of the glycogen content. Most esteem it highly, while others[16] consider it valueless. All agree that the biological serum test is reliable, but it has its limitations in that it cannot be used to detect flesh that has been cooked.

Dr. Esser[2] mentions the fact that experiments using dogs have shown that horse flesh is as digestible as beef, but does not give any data. No data substantiating this fact seems to be available.

Composition of Horse Flesh. Like all other flesh, that of the horse consists mainly of protein and fat. Kohler[17] has investigated the elementary composition of the muscular tissue of various animals, among them the horse. The material was freed as fully as possible of fat by ether extraction and the residual fat determined by Dornmeyer's digestion, for which correction was made. The following data gives his average results for the fat and ash free substance.

Elementary Composition of Flesh.

	No. of Samples	Carbon o/o	Hydrogen o/o	Nitrogen o/o	Sulphur o/o	Oxygen o/o	Heat of combustion per gram (calores)
Cattle	4	52.54	7.14	16.67	0.52	23.12	5.6776
Sheep	2	52.53	7.19	16.64	0.69	22.96	5.6387
Swine	2	52.71	7.17	16.60	0.59	22.95	5.6758
Horse	3	52.64	7.10	15.55	0.64	24.08	5.5990
Rabbit	2	52.83	7.10	16.90	- - - - - -		5.6166
Hen	2	52.36	6.99	16.88	0.50	23.28	5.6173

Horseflesh was the only one of these samples that gave a positive test for glycogen. It gave an average content of 3.65 per cent, which accounts for the low nitrogen content.

According to J. Smorodinzew,[18] fresh horse flesh was found to contain carnosine (1.82 per cent), methylguanidine (.11 - .83 per cent) and carnitin (.17 - .2 per cent). The muscle of the calf and pig are also found to contain methylguanidine and carnitin. Leach[19] says that taurin is also precent in horseflesh.

Like the flesh of any other species of animals the composition of horseflesh varies, according to the age, degree of fatness, etc. The following table from Leach gives the composition of fresh horse and bovine flesh.

Composition of Bovine and Horse Flesh[19]

	Fresh Beef Flesh			Fresh Horse Flesh		
	Average	Maximum	Minimum	Average	Maximum	Minimum
No. of Analyses	5			16		
Water	68.19	71.19	55.81	69.81	71.91	52.16
Fat	12.60	15.33	9.89	9.61	33.66	1.24
			Nitrogen			
Total	3.02	3.19	2.83	3.11	3.60	2.13
Insol. in Hot Water	2.41	2.53	2.32	2.37	2.97	1.33
Ppt'd by Bromine	0.19	0.24	0.14	0.20	0.36	0.12
Meat Bases	0.43	0.53	0.33	0.55	1.22	0.15
			Nitrogenous Substances.			
Protein*	18.89	19.94	17.69	19.47	22.50	13.31
Protein Insol. Hot Water (Coag.)	15.08	15.75	14.50	14.83	18.56	8.31
Gelatinoids and Prop. Ppt'd. by Bromine	1.21	1.50	0.87	1.23	2.25	0.75
Meat Bases	1.29	1.65	1.02	1.70	3.81	0.47
Total Ash	0.96	1.13	0.78	1.01	1.27	0.63
Total NaCl.	0.08	0.24	Trace	0.01	0.09	Trace

* Nitrogen x 6.25

The table shows that beef flesh has a NaCl content that averages eight times as great as in horse flesh.

The fat (adipose tissue) of the horse has some characteristics that distinguish it from other animal fats.

1. High Olein content.
2. Low melting point.
3. High specific gravity.
4. Characteristic crystaline form.
5. High heat value.
6. High iodine number.

The subcutaneous and kidney fat of the horse is light golden yellow, and the mesenteric fat, brownish-yellow. In fattened horses the whole adipose tissue may become of a pure white color. The fat is soft and oleacious (high content of olein). It begins to meet at 30° C, and renders a white horse grease which begins to meet at 32° C. (96 o/o Olein). The bone marrow is waxy and yellow. It hardens on exposure to the air taking on a greenish sheen, and melts at 65° C.

The two most important of the above characteristic of the horse fat are the high iodine value and the high specific gravity. Four commercial samples of the fat of about the same consistency upon purification were analyzed by Kilmont, Meisl and Mayer,[20] and gave the

following values.

Iodine Value	74.9	78.1
Specific Gravity	0.9148	0.9461
Acid Value	1.40	2.91
Melting Point	20°	41° C.

Oleic, linolic, and linolenic acids were detected in the liquid portion of the fat. When crystalized from acetone to which 1/20 of its volume of chloroform was added the solid portion yielded a glyceride which melted at 60° C. and gave a saponification value 197. These investigators identified the fatty acid which separated from this glyceride as heptadecylic acid (margaric acid) which meets at 57° C, and gets a neutralization value of 208. The fatty acid from goose fat described as an eutectic mixture of stearic and palmitic acids also actually consists of heptadecylic acid.

In studying how far the iodine value could be relied upon as a method of detecting horse-fat Dunlop[21] studied the fat from different parts of the horse. The following data is the result of his work.

Constants of Horse Fat and "Horse" Oil.

	Color and Consistency	Iodine Value (Wigs)	Ziess Refracto meter at 25° C.	Saponification Value o/o	Unsaponification Matter o/o	Specific Gravity at ° (15.5° C.)	Free Acid o/o	Reichert Wollny Number
I Horse fat from belly	Orange yellow butter-like	85.66	59.8*	19.84	.54	- - - -	8.80	- - -
II Horse fat from Neck (Mane)	Light yellow part liquid	86.70	61.2	19.91	---	- - - -	0.56	- - -
Horse oil after filtration at 12.2° C.	Lemon yellow oil	90.10	61.8	- - -	0.46	0.9182	- - -	0.30
III Horse fat from neck (Mane)	Light yellow part liquid	90.07	61.2	- - -	---	- - - -	- - -	- - -
Horse oil after filtration at 8.9° C.	Lemon yellow oil	93.11	61.8	19.56	0.50	0.9184	1.20	0.20
IV Horse fat from Kidney bed	Orange yellow part liquid	110.65	66.0	- - -	---	- - - -	- - -	- - -
Horse oil after filtration at 13.3° C.	Orange yellow oil	114.85	66.7	19.63	0.68	0.9212	- - -	0.35
V Horse oil from neck fat	Lemon yellow oil	112.85	66.0	19.63	0.42	0.9211	0.46	- - -
VI Neat's foot fat as extracted from calves feet	White like soft lard	71.80	59.0	- - -	---	- - - -	- - -	- - -
Neat's foot oil after filtration at 13.3° C.	Pale straw color	74.07	59.5**	19.70	0.42	0.9164	0.78	- - -
VII Marrow fat from Ox bones	Light yellow hard like lard	52.04	55.3	19.63	---	- - - -	0.22	- - -

*The low refraction is no doubt due to the influence of free fatty acid.

**Calculated.

The following values for different bovine fats are those given by Moulton and Trowbridge[22] of the Missouri Agricultural Experiment Station.

	Iodine	Saponification Value o/o	Specific Gravity	Melting Point
Cod Fat	43.89	19.77	0.8589	42° C.
Outside Chuck Fat	46.68	19.91	- - -	- - -
Kidney Fat	33.99	19.66	0.8604	47.05° C.

On comparing these figures for horse and bovine fat it seems that:

1. The kidney fat of the horse has the highest iodine value while in the bovine fat it has the lowest. The iodine value of thehorse carcass decreases from the inside to the outside. In the carcass of a beef the reverse is true.

2. The specific gravity of horse fat is about .05 higher than that of a beef fat.

The table shows horse fat to have an unsaponifiable matter content of from 0.42 to 0.68 per cent, which is somewhat higher than that recorded for lard, tallow, etc. The ethereal[20] solution of the unsaponifiable matter has an intense color which appears to be characteristic of this fat.

Dunlop states that his sample No. IV. gave a distinct color reaction with sulphuric acid, such as is often given by partially oxidized liver oil. Lewkowitsch[20]

mentions a sample of genuine horse's foot oil which gave several color reactions characteristic of marine animal oils.

As horse fat has a high content of unsaturated fatty acids, as shown by high iodine value it is a drying fat. It is classified as a semidrying oil (fat). All drying oils have linolic acid as a common constituent. Dunlop calls attention to the marked drying properties of his samples of horse oil Nos. IV and V. These oils when exposed in thin layers on glass to a temperature of 95° C. to 97° C, after two hours gave sticky films, whilst, after four hours the oils became solids.

Horse oil is certainly inferior to genuine lard and tallow oils as a lubricant. This is shown by the following viscosity[20] tests on a sample of horse oil from neck fat by Redwood's viscosimeter -

at 21.1° C. - - - - 286 seconds
at 32.2° C. - - - - 180 seconds
at 60.0° C. - - - - 80 seconds

PART II.

EXPERIMENTAL.

In the experimental work done two horses were slaughtered. The slaughtering was done in practically the same way as for a beef.[23] The first was a mare in fair condition of flesh, not fat, 17 years of age; the second (Prince) a large horse, fat and about 25 years of age. No data was taken on the slaughtering of the mare, and subsequently only the analysis of the flesh, and of the cold water extract of the flesh was made. When Prince was slaughtered the dress, and the weight of his internal organs were taken. These are shown in Table I, along with that of Steer 512, which was used in the Use of Food Experiment, of the Missouri Agricultural Experiment Station.

The carcasses of these two horses were cut into market cuts and given as horse flesh to people of Columbia, Missouri, to eat. Some families used it exclusively for their meat as long as the supply lasted and expressed their liking for it. Others tried it several times but did not seem to relish it, apparently letting their sentiment get the best of them.

The following points were observed in regard to the flesh and fat of these two animals.

1. There was no intermixing of adipose and muscular tissue.

2. It has a peculiarly sweet odor, that was repulsive to some. (This sweetness may be due to the hydrolysis of glycogen to dextrose).
3. The meat is conspicuously dark red or even brown in color. When freshly cut and exposed to the air it has a bluish luster and later turns to a blackish red, or even black color.
4. The fat is soft, oily and of a light gold to dark yellow in color.

   In Prince, the fatter of the two it was much lighter in color.
5. The cooked flesh had a flavor practically the same of that of cooked beef.
6. When cooked the meat was tougher than beef.

   But this was not true in the case of the tenderloin, which proved to be exceedingly tender.

From the age of the animals and their use for work, one could expect their meat to be tougher. Some of the housewives claimed that they could roast it in a manner so that it was as tender as the beef that they could purchase at the local meat shops.

7. The flesh was kept in coolers at about 35° and was noticed to keep much better than the beef on hand. But this was not true of the liver, which blackened in a few days and had to be thrown away.

Plates I, II, III and IV show the carcasses and the different cuts of the horse and the beef. On com-

Table I.

Weights of Offal and Dressed Carcass

Parts of Animal	Horse - Prince	Steer - No. 512*
Live Weight	1430.00 lbs.	1208.25 lbs.
Dressed Carcass	937.00 ,,	785.25 ,,
Percent Dress	65.52 o/o	64.99 o/o
Heart	8.00 lbs.	4.30 lbs.
Liver	12.50 ,,	9.72 ,,
Tongue (marketable)	3.75 ,,	3.78 ,,
Lungs	12.00 ,,	8.54 ,,
Spleen	3.25 ,,	2.76 ,,
Hide and Hair	88.00 ,,	90.79 ,,
Kidneys	- - - -	2.36 ,,
Stomach	2.00 ,,	24.50 ,,
Small Intestines	12.00 ,,	6.75 ,,
Length	88.00 feet	147.00 feet
Large Intestines	37.00 lbs.	4.96 lbs.
Length	25.00 feet	35.00 feet
Pancreas	- - - -	1.62 lbs.

*Steer 512 was of about the same degree of fatness as Prince and considered normal. The dress of the two will be noted as about practically the same.

paring the cuts of the carcasses it is noted that in the horse the ribs are narrower and more exposed, being covered only by a thin membrane, also the difference in the shape of the neck and round. It is seen that in the horse the fat is deposited mostly on the belly, there also being a thick layer over the ribs.

It was impossible to get beef cuts to correspond exactly to those of the horse, but as near representative as possible were taken. The main difference noted is that the horse flesh is coarser than the beef flesh. The white which shows up in the lean of the horse flesh is not fat as in the case of beef but is connective tissue.

Analysis of Horseflesh. The flesh samples analysed were thoroughly ground and evenly mixed in a rotary knife meat grinder. The sample was analyzed for moisture, fat, nitrogen, ash, and phosphorus. For moisture a portion was weighed out and evenly worked into a piece of cotton from a tared prepared glass extraction cone. The cotton with sample was returned to cone, the cone placed in a vacuum desiccator and dried to constant weight over sulphuric. The loss in weight was recorded as moisture. The dried cone was extracted for sixteen hours with ether in a Soxhlet extractor, and dried in vaccuo to constant weight. The loss in weight here was recorded as fat. The nitrogen, ash and phos-

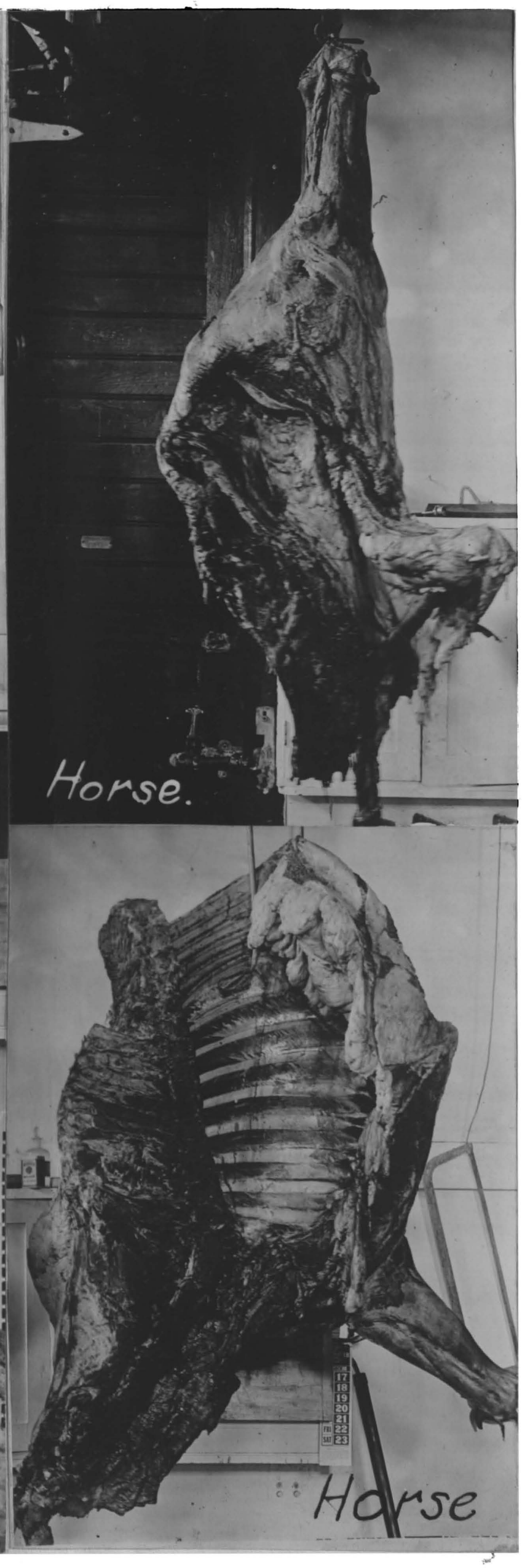

Plate I.


Standing Rib
Horse


Porterhouse
Horse

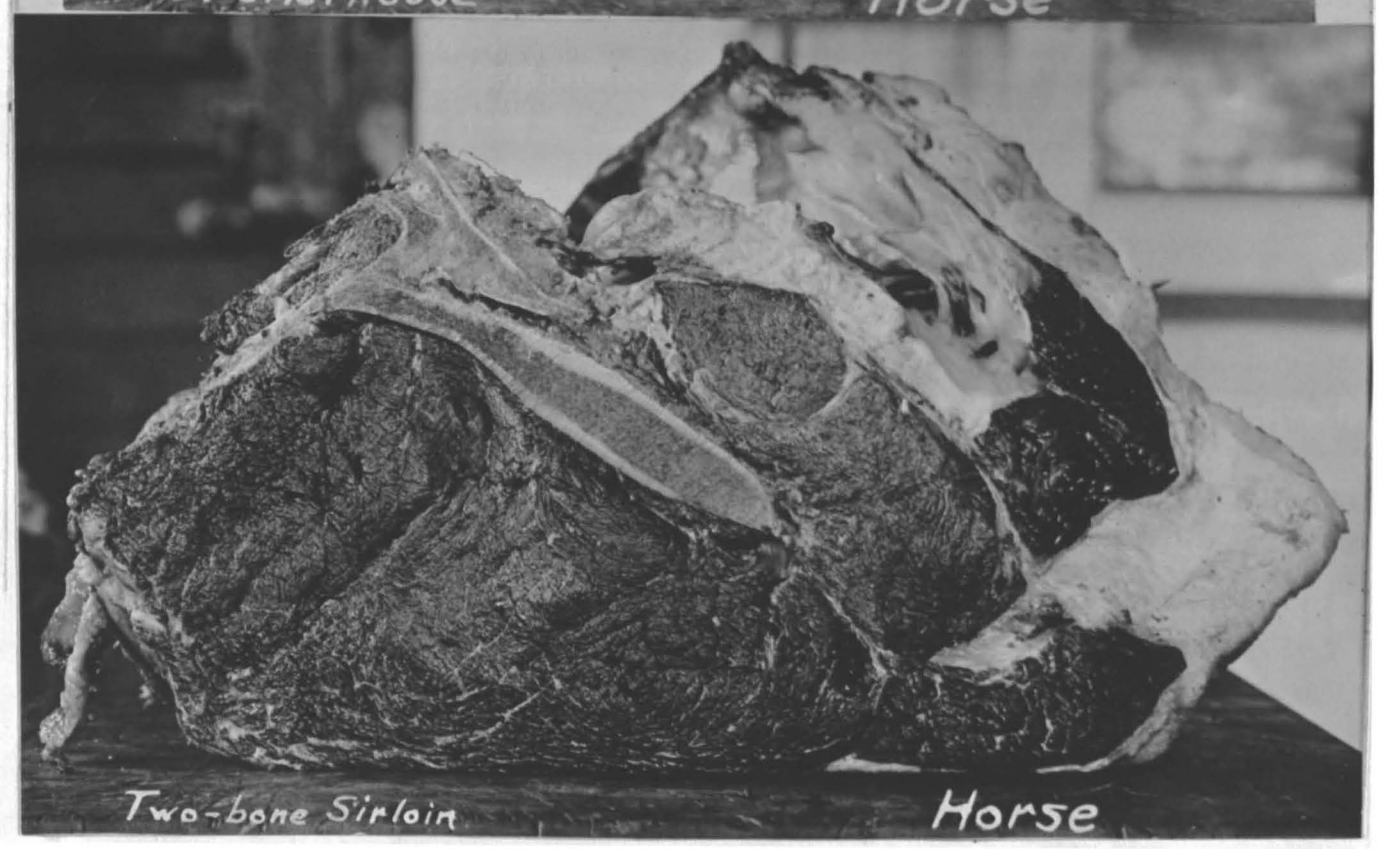
Two-bone Sirloin
Horse

Plate II

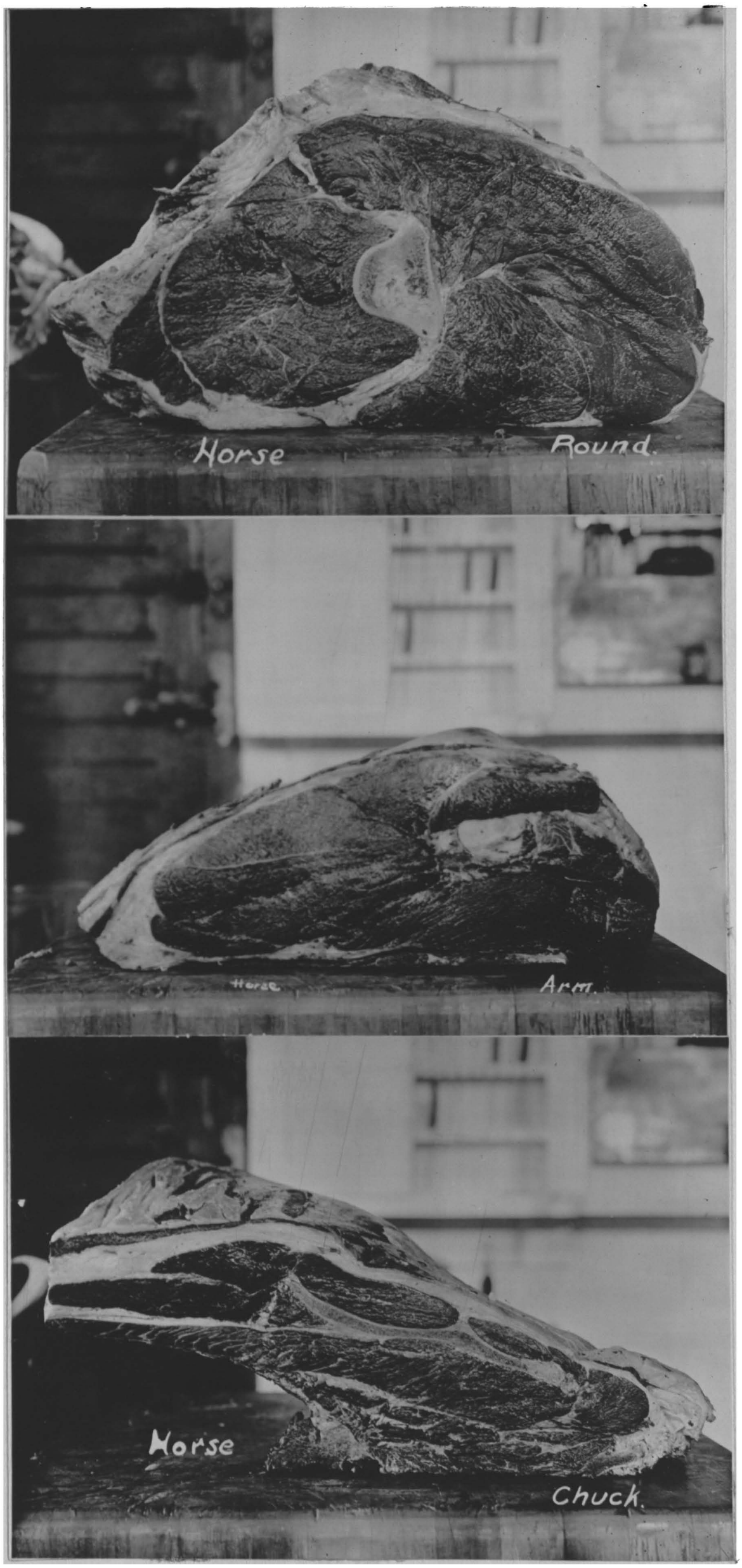

Plate - III

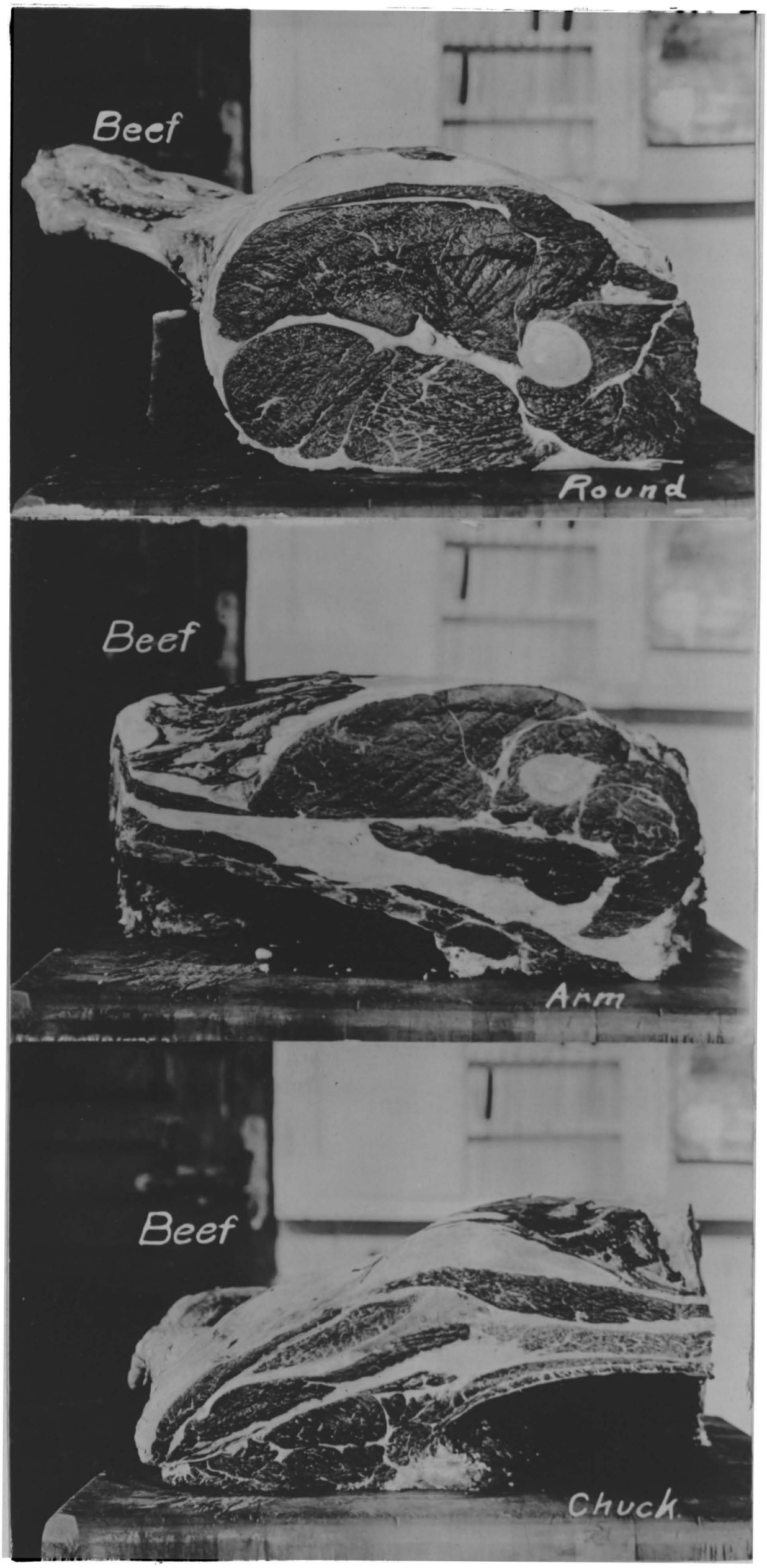

Plate IV

phorus was determined by the official A. O. A. C. methods. The protein was found by multiplying the nitrogen content by the factor 6.25. The results of the analysis are given in Table No. II., and in the same table are compared with the results of the analysis of the Round Lean of Steer 512.

Table No. II.

Analysis of Flesh.

	Mare	Prince		Steer 512
Lab. No.	18-2-61	18-4-13	18-4-14	
	o/o	o/o	o/o	o/o
Moisture	73.3735	60.218	61.298	73.272
Fat	2.625	17.775	17.645	4.557
Nitrogen	3.5015	3.045	2.760	3.237
Protein (N. x 6.25)	21.88	19.03	17.25	20.23
Phosphorus	.1600	- - -	- - -	.192
Ash	1.1230	.867	.920	1.024

Analysis of the Cold Water Extract.[27]

Preparation of the water extract. Of the lean meat 240 grams was weighed out and distributed in twenty 100 c.c. beakers, numbered from 1 to 20, in approximately equal portions. Measured out 50 c. c. of recently boiled and cooled nitrogen free water. Moistened the

portion in beaker No. I. and mixed with a stirring rod until the whole 50 c.c. of water had been added. Repeated this with each of the 20 beakers. Allowed the mixture to settle and stirred again. Repeated this two or three times. In the mean time fitted 20 long stemmed funnels with 11 c. m. No. 595 S. and S. filters using nitrogen free water. Placed 300 c.c. flasks to catch filtrate. Poured the extract from the meat thru the corresponding filter, keeping the major portion of the residue in the beaker. Added 25 c.c. nitrogen free water to each residue and mixed thoroly, and filtered as before. Repeated this eight times, making 250 c.c. extract in each separate extraction, filtered completely before adding the following one. With the last 25 c.c. water transferred the residue to the filter and washed twice with 10 c.c. portions of water. Combined the filtrates and made up to six liters, and filtered thru a dry filter. One hundred cubic centimeters of this extract represented four grams of the sample.

Samples taken for Analysis.

A.	3 samples	100 cc	each	Total nitrogen
B.	2 ,,	100 cc	each	Solids and Ash
C.	2 ,,	500 cc	each	Total Phosphorus
D.	3 ,,	600 cc	each	Organic Phosphorus
E.	3 ,,	200 cc	each	Coagulable and Amino Acid Nitrogen.
F.	2 ,,	750 cc	each	Creatin

A. Total Nitrogen. Added 25 cc conc H_2SO_4, and 7 grams mercury to portions in nitrogen flask, After expulsion of water added about 7 grams K_2SO_4 and proceeded as directed under the determination of nitrogen in fresh sample of meat.

B. Solids and Ash. Evaporated portions in tared platinum dishes to dryness on water bath and heated to constant weight in an oven at 104° C. Cooled and weighed. Results gave total solids. For ash the dish was heated to dull redness to complete combustion.

C. Total Phosphorus. The portions were evaporated to a small volume and with a little hot water washed into nitrogen flasks. Added 15 cc conc. H_2SO_4 to beakers and heated gently, moistening the sides of the beakers with the acid to remove coagulum and transferred to the corresponding flask. Added 0.7 grams mercury and about five grams K_2SO_4 and digested as for determination of nitrogen. Determine the phosphorus as per A. O. A. C. method for fertilizers.

D. Organic phosphorus. To each of the portions for this determination added 5 cc 10 per cent solution $BaCl_2$, 10 cc of NH_4OH (1-1) and 45 cc H_2O, making a volume of 660 cc. Mixed and let stand over night. Filtered thru dry filter and took 605 cc of filtrate, representing 22 grams of sample of lean meat. To this added 10 cc of K_2SO_4 (5 per cent solution) and 45 cc

of water (total volume 660 cc). Mixed well and allowedthe precipitate to settle. Carefully decanted exactly 600 cc of solution representing 20 grams of the sample of lean meat and transferred 600 cc filtrate to 800 cc beakers and acidified with sulphuric acid. Concentrated the solution to a small volume on water bath and proceeded exactly as directed for the determination of total phosphorus as given above.

E. Coagulable and Amino Acid Nitrogen.

1. Coagulable Nitrogen. To the portions for this determination added a slight excess of moist freshly precipitated $MgCO_3$. Concentrated to about 10 cc on water bath and filtered thru a 9 c.m. 595 S. and S. filter catching filtrate in a 100 cc graduated flasks. Washed residue thoroly with hot water, keeping volume of filtrate below 60 cc.

Dissolved coagulum in precipitating vessel with 25 cc. H_2SO_4 and transferred it and filtered into a nitrogen flask. Continued as for determination of total nitrogen.

2. Amino acid nitrogen. Added 15 grams NaCl to each filtrate from coaguable nitrogen determination, and shook well. Placed flasks, 24 percent tannic acid solution, and flask of nitrogen free water in cooler. When cooled to 15° C. added to each flask 30 cc of the tannic acid solution, filled to mark with cold water and after mixing thoroly let stand in cooler over

night. Filtered rapidly thru dry filters and transferred 50 cc of each filtrate to nitrogen flasks. Added 0.7 grams mercury and 35 cc H_2SO_4 and continued as for total nitrogen. Special blanks were made of the reagents using full amounts.

F. Creatine. Concentrated the portions on water bath to about 50 cc each, filtered and washed with hot water, catching filtrate and washings in 200 cc beakers. Evaporated to about 10 cc. Refiltered and washed with hot water, catching filtrate and washings in 100 cc. graduated flasks, and keeping volume below 50 cc. To each flask added 25 cc normal HCl and heated for 25 minutes in autoclave at 117 to 119 C. Cooled completely and added 25 cc. normal NaOH and made to mark with water.

Transferred 40 cc of these solutions to 500 cc graduated flasks and added 25 cc. 1.2 percent picric acid solution. Mixed and added 10 cc 10 percent NaOH solution. Shook for one half minute and allowed to stand exactly 4 1/2 minutes. Diluted to mark and mixed immediately. Compared color of the solution with that of half normal K_2Cr_2O, in a Dubosc Colorimeter set at 8 mm. (Aliquot may have to be varied to obtain approximately this reading).

Divided the reading into 16.2 to obtain the weight in milligrams of creatinine in 100 cc of the solution read. Multiplied this weight by 1.16 to obtain the

corresponding creatin equivalent. On basis of aliquot taken calculated the percent of creatin in the fresh sample.

The results obtained on a sample of lean flesh from the first horse killed are given in Table III.

Table III.

Analysis of Cold Water Extract of Flesh.

	Mare	Steer 512 Round lean
	o/o	o/o
Nitrogen		
Total	0.6596	0.677
Coagulable	0.3816	0.310
Amino Acid	0.1437	0.227
Solid Matter	6.745	- - -
Ash	0.9872	- - -
Phosphorus		
Total	0.1408	0.135
Organic	0.05833	0.048
Creatin	0.22629	0.296

In Table No. III , is shown the analysis of the cold water extract of the round lean of Steer No. 512. This sample was selected as it gave near the same analysis as that of the horse, as will be seen from

Table No.II. On comparing Table II and III it is noted that the cold water soluble phosphorus of the flesh of Steer 512 is 70.3 per cent while that of the horse flesh is 88 per cent.

Digestibility of Horseflesh.

The purpose of the digestion trials, to be discussed in this paper, was to determine the digestibility of the protein and fat in horse flesh as compared with that in raw bovine flesh.

The animals used in these trials were two small female dogs, secured from the local dog catcher, and designated as Dog No. I and Dog No. II. At the beginning of the trials Dog No. I weighed 14 pounds (6.36) kilos and Dog No. II, 21 pounds (9.55) kilos. The trials were designated as Trials 1 and 1a (horse), 2 and 2a (bovine), 3 and 3a (horse) and 4 and 4a (bovine). The trials suffixed by ''a'' were those on Dog No. II.

As indicated the dogs were fed on rations of both horse and bovine flesh. For each set of trials, as for 1 and 1a, sufficient flesh to feed both dogs for the preliminary and trial periods was thoroly ground and evenly mixed in a power rotary knife meat grinder. It was stored in large cans and kept in the freezing room of the coolers.

Daily ration. For the horse flesh trials 1 and 1a the dogs were fed a daily ration of 1 pound for dog No. I, and 1.5 pounds for dog No. II. But as this

was found to be too large a ration, both by the fact that both dogs refused some of the ration, and by subsequent calculation, for the other trials Dog No. I was given a daily ration of one half pound and Dog No. II one pound. The weight of the flesh fed during each trial period is recorded in Table IV.

Calculation of Daily ration. The generally accepted formula[24] $K = S/W^{2/3}$, gives the relation between weights and the surface of an animal. For the dog the constant K has been determined as 11.2[24]. The surface is considered as directly proportional to the heat required. Lusk[25] showed that the heat value of a mixed ration that maintained a dog at constant weight for six months as 1380 calories per square meter of surface. Knowing that Dog No. I. weighed 6.36 kilograms, and Dog No. II. 9.56 the heat value of the ration for Dog I was calculated as 503.6 calories and for Dog No. II as 697.7 calories. Lusk in arriving at his value gave protein as 4.1 calories per gram and fat as 9.4 calories per gram. Knowing the weight and analysis of ration the heat value of ration was calculated and shown in Table IV. These figures show that the dogs were fed a ration above maintenance except in trial No. 4. which was 27.56 calories below maintenance.

Sampling rations. As the bulk ration was being ground small portions were taken from various parts of the mass and combined. The combined portions were

Table IV.

Heat Value of Rations.

Trial	Dog No.	Calories Offered	Calories Required	
		(Horse)		
No. 1	Dog I	1114.17	503.6	+610.57
No. 1a	Dog II	1671.46	697.9	+973.56
No. 3	Dog I	538.36	503.6	+ 34.76
No. 3a	Dog II	1075.3	697.9	+377.4
		(Bovine)		
No. 2	Dog I	658.3	503.6	+154.7
No. 2a	Dog II	1316.57	69.79	+618.47
No. 4	Dog I	476.04	503.6	- 27.56
No. 4a	Dog II	952.70	697.9	+254.8

reground and remixed and analyzed.

Analysis of ration. This sample of the ration was analyzed for fat and protein. For fat a portion was weighed out of a weighing bottle by difference and worked into a piece of cotton. This was placed in a paper glass fat-free cone and dried to constant weight in a vacuum desiccator over sulphuric acid and then extracted with ether, and dried again. The fat was determined by difference. For protein a sample was similarly weighed out and run for nitrogen by the A. O. A. C. method. Protein calculated by multiplying the percentage of nitrogen by the factor 6.25. Table VI. shows the results of the analysis.

Feeding. The dogs were fed once a day, in the morning, at the same time they were given plenty of water and salt. At times they refused a part of their ration. That which was not readily eaten was removed and weighed and as it had been exposed for so short a time, no changes could take place but an evaporation of moisture, which was assumed to be negligible, its weight was subtracted from the weight of the ration offered. The difference was the weight of the ration consumed. The weight of feed consumed is shown in Table V.

Feces. As soon after feces were voided as possible, they were removed and transferred to glass jars which were kept in the freezing room of the coolers. The dogs were kept in metabolism cages which were provided with

removable, one quarter inch mesh screen bottoms, from which the feces could be readily removed with little loss. Their weights were recorded in Table V.

This method of preserving the feces for analysis was considered best as results of work done at the Ohio Experiment Station by Forbes, Mangels and Morgan.[26] They found that the chemical composition of feces did not vary whether the feces were kept frozen for 20 days with or without thymol, or by drying the fresh material with or without thymol.

Preparation of fecal samples. At the end of a trial the combined feces of that trial and the container was placed in a vacuum desiccator and dried to complete dryness over sulphuric acid. The dried feces were removed from the container and ground as rapidly as possible to pass thru a one hundred mesh seive. When ground they were exposed in open dishes and allowed to acquire atmospheric moisture. The constant air dry weight was taken as the weight of the feces.

Analysis of the feces. The fecal samples were analyzed for fat and protein, for fat by ether extraction in a Soxhlet Extractor and for protein by multiplying the nitrogen content, determined by the A. O. A. C. method, by the factor 6.25. Table VII gives the results of the analysis.

From the weights and analyses of rations and feces

the digestibility of the fat and protein was calculated. The results of the calculation are shown in Tables VIII and IX.

Source of Error. Besides the possible loss of feces as a source of error, there are the facts that nitrogenous substances are returned to the feces, and that as the dogs shed some, the feces were contaminated with some hair.

Table V.

Feeding Data.

Trial No.	Dog No.	Weight of Ration	Weight of Ration Refused	Weight of Ration Consumed	Weight of Feces
		grs.	grs.	grs.	grs.
Horse Flesh Trials.					
No. 1	I	5909.1	1685.4	4223.7	54.30
No. 1a	II	8807.7	3005.7	5801.6	92.70
No. 3	I	2,272.7	- - -	2272.7	23.50
No. 3a	II	3,409.05	- - -	3409.1	27.90
Bovine Flesh Trials.					
No. 2	I	9254.51	- - -	2954.5	44.60
No. 2a	II	4431.8	1051.1	3380.7	42.70
No. 4	I	2272.7	- - -	2272.7	36.70
No. 4a	II	3409.09	142.05	3267.04	33.10

Table VI.

Analysis of Ration.

Trial No.	Laboratory No.	Per Cent Nitrogen	Per Cent Protein (N. x 6.25)	Per Cent Fat
Horse Flesh Trials.				
1 } 1a }	18-4-13	3.045	19.03	17.775
3 } 3a }	18-4-14	2.760	17.25	17.645
Bovine Flesh Trials.				
2 } 2a }	18-4-19	2.801	17.52	23.165
4 } 4a }	18-6-57	3.0747	19.22	13.886

Table VII.

Analysis of Feces.

Number of Trial.	Laboratory No.	Nitrogen o/o	Protein o/o (N. x 6.25)	Fat o/o
		Feces Horse Flesh Trials.		
1	18-5-22	6.758	42.238	17.670
1a	18-5-23	7.820	48.875	12.052
3	18-6-51	7.074	44.213	18.297
3a	18-6-52	7.720	48.250	12.148
		Feces Bovine Flesh Trials.		
2	18-5-28	7.818	48.863	13.923
2a	18-5-29	5.770	36.063	12.025
4	18-6-58	5.497	34.356	19.645
4a	18-6-59	6.537	40.856	16.223

Table VIII.

Digestibility of Fat.

Trial No.	Fat in Ration (grams)	Fat in Feces (grams)	o/o Fat Voided in Feces	o/o Fat Digested
Horse Flesh Trial.				
1	750.76	9.595	1.278	98.722
1a	1031.23	11.172	1.012	98.988
3	401.02	4.300	1.072	98.928
3a	601.54	3.389	.563	99.437
			Average	99.019
Bovine Flesh Trials.				
2	684.41	6.210	.907	99.093
2a	783.14	5.135	.656	99.344
4	315.59	7.210	2.287	97.715
4a	453.66	5.370	1.184	98.816
			Average	98.742

Table IX.

Digestibility of Protein.

Trial No.	Wt. Protein in Ration (grams)	Wt. Protein in Feces (grams)	o/o Protein Voided in Feces	o/o Protein Digested
		Horse Flesh Trials.		
1	803.77	22.935	2.853	97.147
1a	1104.04	45.307	4.104	95.896
3	392.04	10.390	2.650	97.350
3a	588.07	13.462	2.289	97.711
			Average	97.026
		Bovine Flesh Trials.		
2	517.63	21.793	4.210	95.790
2a	592.30	15.399	2.600	97.400
4	436.81	12.793	2.887	97.113
4a	627.93	13.523	2.154	97.846
			Average	97.037

SUMMARY.

From the observations taken the following considerations were noted.

1. The dress of a horse carcass is practically the same as that of a beef of the same conditions of flesh.

2. The flesh of the horse was sweet, course, conspicuously dark red in color. The flesh is tougher than that of beef.

3. The fat is soft, oily, and light yellow in color. (It is composed of the glycerides of hepterdecylic and unsaturated fatty acids, having an unusually large percent of the latter.)

4. The carcass can be easily distinguished from that of bovine by its shape, the appearance of the ribs, and the distribution of the fat.

5. The analysis of horseflesh, and of the cold water extract of horse flesh gave practically the same results as those given by a similar sample of beef flesh. The phosphorus in horse flesh appears to be more soluble in cold water than that of beef flesh.

6. The digestion trials showed that in the case of horseflesh the protein was 97.026 per cent digestible and the fat 99.019 per cent digestible, while in the case of beef flesh the protein was 97.037 per cent digestible and the fat 98.742 per cent digestible. The difference is so small that horse flesh may be considered as digestible as beef flesh.

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UNIVERSITY OF MISSOURI
COLUMBIA

PARTMENT OF PHYSIOLOGY

December 12, 1919

Dean Walter Miller,

Graduate School.

My dear Dean Miller:-

I recommend for acceptance the inclosed dissertation by Mr. T.H. Hopper. I would suggest as a slight revision which can be preferably included, a greater amount of self-criticism. On page 45, for example, is discussing sources of error, it would be desirable to cite authority upon the question of whether ability to digest meats run parallel in men and dogs.

In preparing the manuscript for permanent form, the writer will surely take note that there is no authority for "reforming" the spelling of names in foreign languages.

The nature of the investigation seems to be of entirely proper form for a Master's Degree.

Very truly yours,

Addison Gulick

AG/REF