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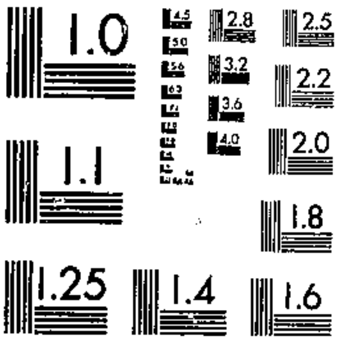

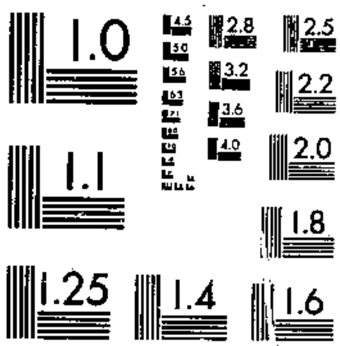

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Nutritive Properties of Pork Protein and Its Supplemental Value for Bread Protein[1]

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INTRODUCTION

Pork ordinarily constitutes about 45 percent of all the meat consumed in the United States. The average per capita consumption of pork during the period 1935–39 was 56.1 pounds, and in 1944 the quantity eaten was 74 pounds.[2] It has been estimated by the National Research Council (*8*)[3] that in 1940 the total production of protein in pork in the United States was 892,800,000 pounds as compared with 2,125,213,500 pounds in all classes of meat, including edible byproducts, or 42 percent of the total meat protein.

Meat is generally recognized as a source of protein of high nutritive value; yet our knowledge of the subject is still inadequate, particularly as regards the nutritive properties of the protein in different cuts and grades of meat and the effects of various factors on the protein. Additional information is also needed on how pork and other meats may be used most effectively in the diet to supplement the proteins in other food products that are known to be deficient in certain essential amino acids.

The purpose of the research herein reported was to determine the digestibility and growth-promoting values of the protein in different dehydrated roasted cuts of fresh pork and the supplemental value of the protein for that in different kinds of bread. For the purpose of comparison, dried whole milk was tested also. The experiments were conducted during 1943–44 in rat-feeding tests at the United States Department of Agriculture, Beltsville Research Center, Beltsville, Md.

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[2] UNITED STATES BUREAU OF AGRICULTURAL ECONOMICS. THE NATIONAL FOOD SITUATION, 21. 19 pp., illus. 1944. [Processed.]
[3] Italic numbers in parentheses refer to Literature Cited, p. 12.

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PREVIOUS INVESTIGATIONS

Hoagland and Snider (*3*) compared the growth-promoting values of the protein in dehydrated raw ham, top round of beef, and shoulder of lamb. When the protein of pork was fed to young rats at a 10-percent level, it had practically the same value as the protein of other meats. In another experiment, the same authors (*4*) determined the nutritive value of the protein in dehydrated raw ham and in both dehydrated raw and cooked beef chuck. Pork had a somewhat higher value than either the raw or cooked beef.

Mitchell, Beadles, and Kruger (*7*), as the result of nitrogen-balance experiments with rats, reported a biological value of 79 for pork tenderloin as compared with an average value of 74 previously obtained for other cuts of pork. In those experiments the term "biological value" indicates the proportion of absorbed nitrogen utilized by the animal. Those authorities stated that in their experience the different cuts of pork possessed rather constant values.

In a recent study of meat dehydration, Hankins and associates (*9*) reported the results of experiments to determine the digestibility and biological values of the protein in precooked dehydrated pork, beef, and mutton. The values for different lots of pork and beef varied considerably, but the average values for the three kinds of meat were similar. The average biological value for the total protein in dehydrated meat was approximately the same as the value for dried skim milk. The protein in dehydrated meat was considerably more digestible, however, than the protein in dried skim milk. In these experiments the term "biological value" indicates the value of the total protein for maintenance and growth.

Information concerning the amino acid content of the proteins in foods is of fundamental importance in the evaluation of the protein. Beach, Munks, and Robinson (*1, p. 435*) determined the quantities of 10 amino acids in 6 soft organs of cattle and in the muscle tissues of a variety of cold- and warm-blooded animals. They state:

> In general it can be seen that muscle tissues of these different classes of animals do not differ widely in their amino acid patterns, which implies that the same amino acid compositiion of muscle proteins is repeated throughout the animal kingdom and indicates that, as far as these 10 amino acids are concerned, the protein of one muscle is as good as that of another in supplying amino acids in the diet.

Block and Bolling (*2*) determined the quantities of 11 amino acids in a variety of animal and plant proteins. The advantage in using amino acid analyses for the nutritional evaluation of proteins in the compounding of foods and feeds was stressed.

There appear to be no published data concerning the supplemental value of the protein in pork for that in cereals and cereal products. For beef, however, data are available which show that the protein has a high value for supplementing the proteins in cereals and certain cereal products.

EXPERIMENTAL PROCEDURE

Description of Products Tested

Two experiments were conducted with cuts from hogs that were slaughtered at different times. The four hogs used in the first experiment were fed corn, tankage, alfalfa leaf meal, linseed meal, middlings, soybean meal, and minerals. They varied from 211 to 226 days in age and from 200 to 215 pounds in weight at the time of slaughter. The carcasses were chilled at temperatures of 33° to 35° F. and were cut 5 days after slaughter by a method that involved the preparation of full-cut head, two-rib picnic shoulders, and short-cut hams. The cuts used in the studies of the nutritive properties of the protein were both picnic shoulders, both shoulder butts, the left ham, and the left loin from each carcass.

The meat was roasted in the following manner: The cuts were placed on racks in open pans and roasted in an electric oven at a temperature of 325° to 350° F. until the internal temperature of each cut reached 155° to 160° F. All roasted cuts and drippings were stored at about 34° until they were dehydrated. The lean meat was separated from the other components, ground, and mixed with the juice, exclusive of fat. The mixture was reground, spread on screen trays, and dried in a current of air at 155° to a moisture content of less than 10 percent. The average cooking time and dehydration time required are shown in table 1. Each of the four samples of dehydrated pork, representing the ham, loin, picnic shoulder, and shoulder butt, was stored in a friction-top tin bucket at 0° until time for fat extraction.

TABLE 1.—*Average roasting and dehydration time for different cuts of pork*[1]

EXPERIMENT NO. 1.—WHOLE CUTS ROASTED

Sample roasted	Average weight of fresh meat	Average roasting time	Average dehydration time
	Pounds	*Minutes*	*Minutes*
Loin	10.85	112	200
Picnic shoulder	7.22	229	205
Shoulder butt	4.32	133	300
Ham	15.16	349	150

EXPERIMENT NO. 2.—WHOLE CUTS AND GROUND MEAT ROASTED

Sample roasted	Average weight of fresh meat	Average roasting time	Average dehydration time
Whole cut of—			
Loin	11.93	191	165
Picnic shoulder	6.78	227	165
Shoulder butt	3.85	139	165
Ham	13.83	345	165
Ground meat of—			
Loin	3.15	101	165
Picnic shoulder	3.15	98	165
Shoulder butt	3.15	97	165
Ham	3.15	94	165

[1] The hogs used in experiment No. 1 were slaughtered Oct. 4, 1943; those used in experiment No. 2 were slaughtered Apr. 20, 1944.

In the second experiment also, four hogs were used. Two were fed corn, tankage, alfalfa leaf meal, linseed meal, and minerals, and the other two received corn, tankage, linseed meal, ground clover hay, and minerals. At slaughter the hogs ranged from 211 to 240 days in age and from 182 to 202 pounds in weight. Slaughtering, chilling, and cutting methods were the same as those used in the first experiment, and the study was concerned with the same cuts.

In the second experiment, however, the picnic shoulder, shoulder butt, loin, and ham from each hog were cooked in two ways: As the entire cut and as ground meat. The purpose of this procedure was to determine the effect of variation in the time of cooking on the nutritive value of the protein. The four cuts from one side of each hog were cooked as in the first experiment. The ground meat from the corresponding cuts from the other side of each hog was roasted in equal quantities in glass baking dishes of uniform size under the same oven and meat temperature conditions. In this experiment also, the cooked whole and ground samples were dehydrated. However, drying was accomplished at an air temperature of 160° F. for a uniform period of 165 minutes. As in the previous experiment, the dehydrated meat from each cut was stored in a friction-top tin bucket at 0° until the fat was extracted. Each lot of dehydrated pork in each experiment was thoroughly extracted with ethyl ether in a percolator and then heated overnight in an electric oven in a current of air at a maximum temperature of 140°. The meat was then ground fine and stored in covered glass jars at approximately 20°. Table 1 gives the roasting and cooking time for each cut in the second experiment.

Enriched white bread, 100-percent whole-wheat bread, and commercial rye bread were obtained from a large bakery in Washington, D. C. The white bread was made from a mixture of equal parts of hard spring wheat and hard winter wheat flours. It was enriched at the bakery by the addition of thiamine, niacin, and iron, in accordance with the requirements of the Food Distribution Administration of the United States Department of Agriculture (*10*). Sufficient condensed milk and dried skim milk were added to supply 4 percent of milk solids. The whole-wheat bread was made from Kansas hard winter whole-wheat flour to which was added 3 percent of dried skim milk. The rye bread was made from a mixture of 70 percent of first-clear wheat flour and 30 percent of dark rye flour.

A number of lots of white bread and one lot each of whole-wheat and of rye bread were used in the tests. Each lot of bread was ground through a meat grinder and then spread in thin layers on shallow trays and dried in a current of air at a maximum temperature of 140° F. The dried bread was ground fine and stored in covered glass jars at 20°. The following amino acids were added to two of the white-bread diets: d-lysine monohydrochloride to one diet and this amino acid, together with dl-valine, to the other diet.

Two lots of dried whole milk of a well-known brand were purchased in vacuum-sealed tin cans.

All lots of dried pork, dried bread, and dried milk were analyzed for moisture, ash, nitrogen, and fat before being used in compounding rations.

Diets Fed

Dehydrated pork, bread, and milk were incorporated in diets in such proportions that each product or mixture supplied 1.6 percent of nitrogen. The following quantities of the B vitamins were added to each 100 gm. of diet in addition to any of these vitamins present in the dehydrated pork, bread, or milk: Thiamine hydrochloride, 0.3 mg.; riboflavin, 0.3 mg.; pyridoxine hydrochloride, 0.6 mg.; calcium pantothenate, 1.5 mg.; and choline chloride, 20 mg.

The fat-soluble vitamins were incorporated in the form of 2.5 percent of refined corn oil, to which were added sufficient vitamins A and D so that 1 gm. of the diet contained 5 International units of vitamin A and 1 unit of vitamin D. Sufficient kettle-rendered lard was added to make 10 percent of fat in the diet. Salt mixture amounting to 4 percent and sufficient dextrin to make 100 percent completed the diet. Diets made up according to the above formula have been found to be adequate for normal growth in rats, except for the limiting factor protein, which was purposely placed at a suboptimum level.

A low-protein diet, fed to the rats during the digestion tests in order to correct for the excretion of so-called metabolic nitrogen, was made up as follows: Dehydrated cooked cured ham, sufficient to supply 0.64 percent of nitrogen, and the other constituents as indicated above. Each diet was made up in the quantity of 1,000 gm. and was stored in covered glass jars at about 40° F. until it was used.

Feeding Tests

Each diet, containing 1.6 percent of nitrogen, was fed to eight male albino rats for 30 days. The rats weighed approximately 40 gm. each and did not exceed 25 days of age at the beginning of the tests. Rats from different litters were distributed evenly among the different groups. Each rat was kept in an individual cage, which was provided with a raised screen bottom, a self-feeder, and a drinking vessel. The bottom of the cage was covered with a sheet of blotting paper. The rats were weighed twice weekly and the quantity of feed consumed was recorded. The temperature of the rat laboratory was maintained at approximately 75° F.

The digestion tests were conducted after the growth experiments had been in progress about 21 days. All feces from each rat were collected for 7 days, and the quantity of feed consumed during the same period was determined. The feces were dried to constant weight at 100° C. Hair was removed from the partially dried feces by a blast of air. The diets and feces were analyzed for nitrogen.

In order to correct for metabolic nitrogen in the feces, the following procedure was followed: At the end of the 30-day growth tests, each rat was changed to the low-protein diet. After a preliminary period of 3 days, the feces were collected for 7 days and the quantity of feed consumed was recorded. The feces were analyzed for nitrogen. Since it had been previously determined that the nitrogen in the low-protein diet was practically 100-percent digestible, it was therefore assumed that the nitrogen excreted by the rats while on this diet was of metabolic and bacterial origin. In the calculation of the true digestibility of the nitrogenous compounds in a diet containing 1.6 percent of nitrogen, correction was made for the nitrogen excreted by each rat when it was fed the low-protein diet, adjustment being made to the same feed intake.

In addition to the actual determinations of digestibility, values were also computed for the mixtures of pork or of milk and bread. These were based on the weighted averages of the values previously determined for the individual constituents.

In the experiments reported, the nutritive properties of the different products were compared in terms of nitrogen, the constituent actually determined chemically, rather than in terms of crude protein, since different factors are commonly used to convert the nitrogen content of meat, milk, and bread into protein. Furthermore, an appreciable proportion of the nitrogenous compounds in meat is not true protein. The term "biological value" indicates the value of either the total or digestible nitrogen, as the case may be, for maintenance and growth expressed as gain in weight per gram of nitrogen consumed.

EXPERIMENTAL RESULTS

Pork, Dried Whole Milk, and Bread

In table 2 are shown the results of experiment No. 1, in which the different cuts of pork were roasted whole. Comparable data for dried whole milk and for different kinds of bread are presented also. The results of the digestion tests indicate little variation in the digestibility of the nitrogenous compounds in the different cuts of pork; all were highly digestible. The nitrogenous compounds in white bread were considerably less digestible than those in pork but somewhat more digestible than those in dried whole milk, whole-wheat bread, and rye bread.

The results of the growth tests suggest that the nitrogenous compounds in the loin and shoulder butt were of higher biological value than those in either the ham or the picnic shoulder. However, table 1 shows that a much longer time was required to roast the ham and picnic shoulder than the loin and shoulder butt, although the final internal temperature of all cuts was approximately the same. These observations suggest that the differences in biological value were due, in part, to differences in cooking time. The average biological value of the nitrogen in the four cuts of pork, when expressed as gain in weight per gram of total nitrogen consumed, was approximately the same as the value for dried whole milk, but when expressed as gain in weight per gram of digestible nitrogen consumed, the average value for pork was slightly lower than the corresponding value for dried whole milk.

Table 2.—*Average biological values and digestibility of nitrogenous compounds in different cuts of pork roasted whole (experiment No. 1), in dried whole milk, and in different kinds of bread, when fed to male rats for 30 days*

Source of nitrogen in diet	Gain in weight	Feed consumed	Gain in weight per gram of—		True digestibility
			Total nitrogen consumed	Digestible nitrogen consumed	
	Grams	*Grams*	*Grams*	*Grams*	*Percent*
Loin	109	309	22.06	22.08	99.6
Picnic shoulder	94	298	19.71	19.90	98.9
Shoulder butt	110	320	21.48	21.66	98.6
Ham	96	303	19.79	20.13	98.1
Average	102	308	20.76	20.97	98.8
Dried whole milk	113	332	21.21	22.31	90.1
White bread	22	196	7.01	7.53	93.0
White bread+1 percent lysine	87	207	18.32	19.68	
White bread+1 percent lysine+0.8 percent valine	75	260	17.93	19.05	94.2
Whole-wheat bread	33	214	9.55	10.69	89.3
Rye bread	18	169	6.79	7.50	90.5

The data in table 2 also indicate that the nitrogenous compounds in white bread (without added amino acids), in whole-wheat bread, and in rye bread were of much lower biological value than those in either pork or dried whole milk, whether the comparison is made on the basis of total or digestible nitrogen. The nitrogenous compounds in whole-wheat bread were definitely superior to those in white or rye bread. When the comparison is made on the basis of digestible nitrogen, the value for white bread plus lysine was only slightly lower than the average value for pork. The addition of both lysine and valine to the white-bread diet did not improve the growth-promoting value of the diet above that when lysine alone was added. The deficiency of the white bread in lysine is clearly apparent, but a deficiency of valine is not indicated. In making these comparisons, it should be remembered that the white bread contained 4 percent, and the whole wheat bread 3 percent, of skim-milk solids. Light and Frey (*6*) report results indicating that white bread made without milk is deficient in both lysine and valine, and Jones and Divine (*5*) indicate that wheat flour is deficient in lysine, valine, and threonine.

Table 3 shows the results of the second experiment. In this test, as already indicated, cuts from one side of the hog were roasted whole, as in the first experiment, whereas the corresponding cuts from the opposite side were boned out and the ground lean meat was roasted under uniform conditions. Table 1 shows considerable variation in the time required to roast the whole cuts, but in the ground state the cuts were roasted in practically uniform time.

When the cuts were roasted whole the biological values varied nearly two points, but when the cuts were roasted as ground meat the values varied a maximum of only one point, in terms of gain per gram of nitrogen consumed. These results suggest that the method of cooking, particularly the time required, affected the biological value of the nitrogenous compounds in the different cuts of pork. More satisfactory results were obtained when the ground lean meat was roasted in glass baking dishes under more uniform conditions than was possible when the cuts were roasted whole.

TABLE 3.—*Average biological values of nitrogenous compounds in different cuts of pork (experiment No. 2) as affected by method of roasting, when fed to male rats for 30 days*

Source of nitrogen in diet	Gain in weight	Feed consumed	Gain in weight per gram of total nitrogen consumed
Whole cut of—	*Grams*	*Grams*	*Grams*
Loin	100	311	19.92
Picnic shoulder	115	342	21.00
Shoulder butt	118	330	21.76
Ham	122	358	21.28
Average	114	338	20.99
Ground meat of—			
Loin	116	342	21.17
Picnic shoulder	129	371	21.68
Shoulder butt	119	338	21.91
Ham	122	364	20.89
Average	122	354	21.41

MIXTURES OF PORK AND BREAD AND MILK AND BREAD

In table 4 are shown the results of the tests with mixtures of meat from the different cuts of pork roasted whole and white bread, and with mixtures of dried whole milk and white bread. There were comparatively small differences between the actual (true) digestive coefficients of the nitrogenous compounds in the mixtures containing the same proportions of the different cuts of pork. The values for mixtures of dried whole milk and bread were slightly lower than the values for corresponding mixtures of pork and bread. The computed digestive coefficients for the nitrogen in mixtures of pork and bread differed only slightly from those determined by experiment. On the other hand, the digestibility of the nitrogen in mixtures of dried whole milk and bread was appreciably higher than the computed value. These results suggest a possible supplemental relationship affecting the digestibility of the nitrogenous compounds in mixtures of dried whole milk and white bread.

Only slight differences were found between the biological values for total nitrogen in similar mixtures of white bread and different cuts of pork. As was to be expected, the value for digestible nitrogen was somewhat higher for each mixture than the corresponding value for total nitrogen. The biological values of the total nitrogen in mixtures of dried whole milk and white bread were approximately the same as the average values for similar mixtures of pork and bread. When the comparison is made on the basis of digestible nitrogen, the values for mixtures of milk and bread were slightly higher than for the corresponding mixtures of pork and bread.

TABLE 4.—*Average biological values and digestibility of nitrogenous compounds in mixtures of different cuts of pork roasted whole and white bread, and in mixtures of dried whole milk and white bread, when fed to male rats for 30 days*

Source of nitrogen in diet	Gain in weight	Feed consumed	Gain in weight per gram of—		True digestibility	
			Total nitrogen consumed	Digestible nitrogen consumed	Actual	Computed
0.8 percent in white bread and 0.8 percent in—	*Grams*	*Grams*	*Grams*	*Grams*	*Percent*	*Percent*
Loin	124	359	21.00	22.42	96.6	96.3
Picnic shoulder	107	327	20.46	21.27	95.8	96.0
Shoulder butt	108	313	21.56	22.36	95.8	95.8
Ham	114	340	20.06	22.10	94.9	95.6
Average	113	335	21.15	22.04	95.8	95.9
1.067 percent in white bread and 0.533 percent in —						
Loin	87	294	18.51	19.30	95.4	95.2
Picnic shoulder	86	290	18.14	18.97	94.0	95.6
Shoulder butt	81	277	18.04	18.95	95.1	94.9
Ham	90	303	18.42	19.47	94.6	94.7
Average	86	293	18.28	19.17	95.0	95.0
0.8 percent in white bread and 0.8 percent in dried whole milk	128	360	21.55	22.84	94.4	91.6
1.067 percent in white bread and 0.533 percent in dried whole milk	99	341	18.09	19.32	93.7	92.0

A comparison of the data in tables 4 and 2 shows that the average biological value of the total nitrogen in mixtures containing equal parts of pork and bread nitrogen was slightly higher than the average value for the pork cuts alone. When the comparison is made on the basis of digestible nitrogen, the average value for the mixtures of pork and bread was appreciably higher than the average value for the pork cuts alone. The biological values for the nitrogen in the mixtures containing 1 part of pork nitrogen and 2 parts of bread nitrogen were somewhat lower than the values for the corresponding pork cuts alone.

In table 5 are shown the biological values of the nitrogenous compounds in the mixtures of roasted ground pork cuts and white bread. These results indicate only slight differences between the different diets that contained the same proportions of pork and bread nitrogen. In other words, the nitrogenous compounds in one cut of pork were approximately as efficient as those in another cut in supplementing the nitrogenous compounds in the bread. A comparison of table 5 with table 3 indicates that the values for the mixtures of equal parts of pork and bread nitrogenous compounds were slightly higher than the values for the ground pork alone. Furthermore, a comparison of table 5 with table 4 shows that the average biological value for the total nitrogen in the mixtures containing equal parts of pork and bread nitrogen is appreciably higher than the value for total nitrogen in a similar mixture of dried whole milk and white bread. The data in table 5 confirm those in table 4 in indicating the high supplemental value of the nitrogenous compounds in pork for those in white bread.

TABLE 5.—*Average biological values of nitrogenous compounds in mixtures of different cuts of pork roasted ground and white bread, when fed to male rats for 30 days*

Source of nitrogen in diet	Gain in weight	Feed consumed	Gain in weight per gram of total nitrogen consumed
0.8 percent in white bread and 0.8 percent in—	*Grams*	*Grams*	*Grams*
Loin	126	356	22.14
Picnic shoulder	120	361	21.73
Shoulder butt	135	377	22.42
Ham	126	351	22.38
Average	128	361	22.17
1.067 percent in white bread and 0.533 percent in—			
Loin	92	306	18.66
Picnic shoulder	96	314	19.00
Shoulder butt	100	325	19.25
Ham	93	307	18.91
Average	95	313	18.96

In table 6 are shown the nutritive values for the nitrogenous compounds in mixtures of roasted whole pork loin and white, whole-wheat, and rye breads. The mixture of pork and white bread had an appreciably higher digestive coefficient than that containing either whole-wheat or rye bread, whether the mixture contained equal parts of pork and bread nitrogen or 1 part of pork nitrogen to 2 parts of bread nitrogen. These results are in harmony with the digestive coefficients for the different kinds of bread alone, as shown in table 2. The computed digestive coefficients agree closely with the values determined experimentally.

When the diets contained equal parts of pork and bread nitrogen, the biological values for the various mixtures differed only slightly whether calculated on the basis of total or digestible nitrogen. When there was 1 part of pork nitrogen and 2 parts of bread nitrogen, the value of the nitrogenous compounds in the diet that contained whole-wheat bread was the highest and the value for the diet that contained rye bread was the lowest, but the difference was not large.

A comparison of the data in tables 2 and 6 indicates that the biological value of pork loin alone was slightly higher, as measured by total nitrogen, than that of equal parts of pork loin and bread nitrogen, but when measured by digestible nitrogen the values were approximately the same. The biological value of nitrogen in pork loin alone was considerably higher than that of mixtures containing 1 part of pork nitrogen and 2 parts of bread nitrogen.

TABLE 6.—*Average biological values and digestibility of nitrogenous compounds in mixtures of pork loin roasted whole and white, whole-wheat, and rye breads, when fed to male rats for 30 days*

Source of nitrogen in diet	Gain in weight	Feed consumed	Gain in weight per gram of—		True digestibility	
			Total nitrogen consumed	Digestible nitrogen consumed	Actual	Computed
	Grams	*Grams*	*Grams*	*Grams*	*Percent*	*Percent*
0.8 percent in loin and 0.8 percent in—						
White bread	124	350	21.60	22.42	96.6	96.3
Whole-wheat bread	124	357	21.73	23.05	94.3	94.4
Rye bread	116	343	21.10	22.35	94.9	95.0
Average	121	353	21.51	22.61	95.3	95.2
0.533 percent in loin and 1.067 percent in—						
White bread	87	294	18.51	19.30	95.4	95.2
Whole-wheat bread	100	328	19.03	20.60	92.3	92.7
Rye bread	86	304	17.68	19.10	92.6	93.5
Average	91	309	18.41	19.67	93.4	93.8

DISCUSSION

The experiments herein reported indicate that the nitrogenous compounds in fresh ham, loin, picnic shoulder, and shoulder butt were of approximately equal nutritive value when the different cuts were roasted as ground meat under uniform conditions. This conclusion appears justified not only from the experiments in which the ground cuts supplied all the nitrogen in the diets, but also when the ground cuts were fed in mixtures with bread. These results are in harmony with the statement by Mitchell and coworkers (*7*) that the different cuts of pork possess rather constant biological values. The somewhat variable results in the experiments in which the roasted whole cuts supplied all the nitrogen in the diets appeared to be due to the differences in time required to roast the various cuts.

The experiments also indicate the marked superiority, in biological value, of the nitrogenous compounds in each cut of pork as compared with the value for each kind of bread, even though the white bread contained 4 percent, and the whole-wheat bread 3 percent, of skim milk solids. The inferiority, in nutritive value, of the nitrogenous compounds in bread is due chiefly to the well-known deficiency of wheat flour in lysine, and perhaps in certain other essential amino acids (*5*, *6*). Apparently, the addition of 3 or 4 percent of skim-milk solids to the breads did not nearly make up this deficiency, but the addition of 1 percent of lysine to the white-bread diet greatly improved the growth-promoting value of the protein. The low nutritive value of the nitrogenous compounds in white, whole-wheat, and rye breads, when each was the sole source of nitrogen in the diet of rats, indicates that these breads will have correspondingly low nutritive values when consumed by humans unless supplemented with foods containing an ample supply of lysine.

When each cut of pork was fed in a mixture with white bread so that each of the two products supplied an equal quantity of nitrogen, the mixtures had as high biological value as pork alone. When the diets contained 1 part of pork nitrogen to 2 parts of bread nitrogen, the mixtures had somewhat lower biological values than the pork cuts alone but much higher values than the breads alone. The significance of these results for human nutrition is that pork supplies in relative abundance the amino acid lysine, in which wheat flour and certain other cereal products are very deficient, as well as other essential amino acids. Therefore, a diet containing equal parts of pork or other animal protein of equally high nutritive value, and cereal protein, or even 1 part of pork protein and 2 parts of cereal protein, will supply mixed proteins of high biological value.

SUMMARY

Experiments were conducted to determine the digestibility and biological, or growth-promoting, value of the protein in hams, loins, picnic shoulders, and shoulder butts from hogs weighing approximately 200 pounds each at slaughter. Tests were also conducted with dried whole milk; white, whole-wheat, and rye breads; mixtures of pork and bread; and mixtures of dried whole milk and bread. Young male albino rats were the test animals.

The protein in all cuts of pork was highly digestible, the average digestive coefficient being 98.8. The coefficient for white bread was 93; rye bread, 90.5; whole-wheat bread, 89.3; and dried whole milk, 90.1.

The biological values of the protein in all cuts of pork were high when the meat was roasted under uniform conditions and were approximately the same as those for dried whole milk.

When white, whole-wheat, or rye bread was the only source of nitrogen in the diet, the protein in each was of much lower biological value than that in pork. Whole-wheat bread was somewhat superior to white or rye bread.

Pork fed in mixtures with bread had a marked effect in making good the deficiency in lysine and possibly in other amino acids. The biological value of the protein in mixtures containing equal parts of pork and bread nitrogen was equal to that in pork alone. In mixtures of 1 part of pork nitrogen and 2 parts of bread nitrogen, the protein was of somewhat lower biological value than that in pork alone but of much higher value than that in bread alone.

When pork was fed in mixtures containing equal parts of pork nitrogen and of nitrogen in white, whole-wheat, and rye breads, the total protein in the three mixtures was of approximately the same biological value. The protein in a mixture containing 1 part of pork nitrogen and 2 parts of whole-wheat bread nitrogen was somewhat superior to that in comparable mixtures of pork and white or rye bread.

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