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VITAMINS IN MEAT

Influence of Chilling Rate and Frozen Storage on B-Complex Vitamin Content of Pork

BEULAH D. WESTERMAN, BESS OLIVER, and D. L. MACKINTOSH

Departments of Foods and Nutrition and Animal Husbandry, Kansas Agricultural Experiment Station, Kansas State College, Manhattan, Kan.

Thiamine, riboflavin, pantothenic acid, and nicotinic acid contents of pork loins aged 1, 3, and 7 days at 30° F. and 7 days at 40° F. and kept in frozen storage for 48 weeks were reported. Animals slaughtered in January had more thiamine in the rib-eye muscle than those slaughtered in June, but the reverse was true for pantothenic acid and nicotinic acid. No seasonal differences for riboflavin were found. The greatest frozen storage losses for thiamine and riboflavin occurred in loins aged 3 days at 30° F. Pantothenic and nicotinic acid losses were the greatest in frozen storage in loins aged 1 day at 30° F.

AFTER SLAUGHTER, it is generally believed that hog carcasses should be chilled and processed as rapidly as possible. This procedure is not always followed. Hogs are sometimes slaughtered at home or at the locker plant and considerable time may elapse before the meat is stored. Many different practices have been followed in the chilling and processing of pork.

The object of the experiments reported in this paper was to compare the procedure, used in many locker plants, of aging the meat for a long period at rather high temperature (7 days at 40° F.) with aging for shorter periods at a lower temperature (1 and 3 days at 30° F.), and for a longer period at lower temperature (7 days at 30° F.).

The rate of chilling and processing, before placing in frozen storage, may produce changes in the vitamin B content of pork, and influence nutritive value. Data reported here deal with changes in the thiamine, riboflavin, pantothenic acid, and nicotinic acid contents of pork loins chilled and processed in four different ways. Comparisons were made on the vitamin content before and after storage.

Few data are available in the literature on this specific problem. The vitamin B content of pork has been reviewed in previous publications (*8–10*).

Experimental Procedure

The 48 animals used in the experiment were supplied by the Department of Animal Husbandry. The hogs were slaughtered, eight in a series, in January and June over a 3-year period. The treatments were as follows: Two hogs were slaughtered, chilled rapidly in a refrigerator at 30° F. for 24 hours, then cut, wrapped, and placed in frozen storage. Two hogs were slaughtered, chilled rapidly at 30° F., and held in a cooler 3 days before cutting and storing. Two hogs were slaughtered, chilled rapidly at 30° F. for 24 hours, then placed in a cooler for 7 days before cutting. Two hogs were slaughtered, chilled slowly at 40° F., and kept at this temperature 7 days. It required 3 days to reduce the internal temperature of the meat to 40° F. The thermometer was inserted in the thickest part of the carcass—i.e., the center of the ham—to determine the internal temperatures. The animals were slaughtered so samples from all eight carcasses were cut and placed in frozen storage the same day.

Each of the loins was divided into four roasts. The anterior roast from the left loin was used for analysis of the fresh pork and the right loin was cooked for palatability tests. The other roasts were weighed, wrapped, frozen, and placed in storage at 0° F. Samples were taken from the anterior to posterior end of the loin, alternating between the right and left loins. After removal from storage, at 8-week intervals up to 48 weeks, the roasts were cut in half and one half was cooked and used for organoleptic tests while the other was used for chemical and vitamin analyses. The meat was thawed, the outside fat removed, and the rib-eye muscle (longissimus dorsi) dissected out and ground three times in a food grinder. To equalize any changes due primarily to freezing, the fresh meat was frozen overnight and thawed before sampling. After thorough mixing, samples were taken for the determination of thiamine, riboflavin, pantothenic acid, nicotinic acid, fat, and water. To equalize some variables, all data were reported on a dry fat-free basis. The moisture was determined by the method recommended for the cooperative meat investigations (*6*) and the fat according to the method of the Association of Official Agricultural Chemists (*1*). The thiochrome procedure of Hennessy (*2*) was used to determine thiamine; the fluorometric method of Peterson, Brady, and Shaw (*5*) for riboflavin; and the microbiological methods of Strong, Feeney, and Earle (*7*) and Krehl, Strong, and Elvehjem (*4*) were used for pantothenic acid and nicotinic acid, respectively.

Table I. Seasonal Differences in Vitamin Content of Pork[a]

(Micrograms per gram)

Treatment	1 day at 30° F.	Days Aged: 3 at 30° F.	7 at 30° F.	7 at 40° F.
		Thiamine[b]		
Jan.	81.4	95.7	91.3	102.1
June	67.6	78.6	65.8	59.9
		Riboflavin		
Jan.	7.2	8.1	3	8.2
June	8.4	8.1	8.6	8.6
		Pantothenic Acid		
Jan.	13.3	14.7	11.5	13.9
June	18.7	17.5	16.8	16.7
		Nicotinic Acid[b]		
Jan.	195	180	157	149
June	252	204	192	202

[a] Each figure represents average of data from 6 animals.
[b] Analysis of variance. Jan. > June for thiamine at 5% level for those aged 1 or 7 days at 30° F. and 7 days at 40° F. | June > Jan. for nicotinic acid ($P < 0.05$) for loins aged 7 days at 40° F.

Results and Discussion

The chemical and palatability tests indicated that pork loins aged for 7 days before freezing deteriorated more rapidly during storage than those aged 1 or 3 days. The differences in the quality of meat aged 1 and 3 days were slight. After 48 weeks of storage, the lean meat from all carcasses, regardless of treatment, was only slightly to moderately desirable and the fat was undesirable. The fat on all carcasses was only slightly desirable after 24 weeks of storage, except for those aged for 1 day.

Initial Vitamin Content Comparisons were made first of the initial vitamin B content of the loins after the different treatments (Table I). Regardless of the treatment, the animals slaughtered in January had a higher thiamine content in the rib-eye muscle than those slaughtered in June. Analysis of variance showed that the differences were significant at the 5% level, for loins aged 1 or 7 days at 30° F. and aged 7 days at 40° F., while the seasonal differences for those aged 3 days at 30° F. were nonsignificant. Seasonal differences probably were influenced by seasonal fluctuations in food. Treatment before storage appeared to influence the thiamine content of the loins from the January animals as those aged for 3 and 7 days at 30° F. and for 7 days at 40° F. had considerably more thiamine than those aged 1 day at 30° F. This did not hold true for those slaughtered in June.

Riboflavin content (Table I) showed no differences before storage that could be attributed to season or treatments. Animals slaughtered in January had less pantothenic acid (Table I) in the rib-eye muscle than those slaughtered in June, regardless of treatment—the reverse of the thiamine content. Nicotinic acid (Table I), like pantothenic acid, was highest in animals slaughtered in June, regardless of treatment. The differences were statistically significant ($P < 0.05$) for the loins aged 7 days at 40° F. Loins subjected to 1 day of aging had the highest nicotinic acid content, decreasing after 3 and 7 days of aging. Averaging the data for 12 animals, the carcasses aged 1 day at 30° F. had 223 γ per gram, dropping to 192 γ per gram after 3 days and to 174 γ per gram after 7 days of aging at 30° F. Evidently longer aging at this temperature causes losses in nicotinic acid content. No changes could be attributed to temperature, as the carcasses held at 30° and 40° F. retained about the same amount of this vitamin.

Effect of Frozen Storage Loins were kept in frozen storage at 0° F. up to 48 weeks. Two loins from each treatment were removed for analysis at 8-week intervals. Average data from 12 loins are shown in Table II.

Thiamine. The thiamine content of the loins after frozen storage is shown in Table II. Loins from the carcasses aged 3 days had a higher content of thiamine, 86 γ per gram, before storage than those given other treatments. The retention after 8-week storage for those aged 1 day was high, 92%, dropping to 87% at 16 weeks and remaining fairly constant for the remainder of the storage period. Loins aged 3 days at 30° F. retained 81% of the thiamine after 8 weeks of storage, with a drop to 74 and 66% at 16 and 24 weeks, respectively. Losses during the 48-week storage period were nonsignificant in loins aged for 1 day but very highly significant ($P < 0.001$) for those aged 3 days at 30° F.

The content of thiamine after 7 days of aging was not so high as after 3 days of aging, 79 γ per gram as against 86. However, the retention after storage was higher, 96% at 8 weeks, falling to 85% at 16 weeks, compared with 81%, dropping to 74%, in the same periods for samples aged 3 days. For the three treatments at 30° F. the thiamine content decreased in frozen storage up to 16 weeks and then remained fairly constant.

Aging 7 days at 40° F. compared with 30° F. produced differences in retention, after storage, of 96% as against 89%, but these differences were nonsignificant. After 24 weeks of storage and throughout the remainder of the storage periods at 40° F., there was a greater retention of thiamine than at 8 or 16 weeks. It has been demonstrated by Kiermeier (*3*) that enzymes retain their activity during the freezing process and in the frozen state as long as liquids are present and as long as the gradually increasing concentration of inhibiting substances does not interfere. Enzyme action progressing slowly over the longer storage period may have aided in increasing the thiamine content. Such a reaction might have been aided by the longer aging period.

Year to year variation ($P < 0.001$) was shown in the loins aged 1 and 7 days at 30° F. but the differences were nonsignificant for those aged 3 days at 30° F. and 7 days at 40° F.

Riboflavin. Table II shows the riboflavin content of the loins before and after storage. Evidently the different treatments had little effect on the initial amount of riboflavin in the loins. The variation was slight, 7.8 γ per gram for those aged 1 day to 8.5 γ per gram for those aged 7 days. Loins aged 1 day at 30° F. had a retention of 88% of riboflavin after 8 weeks of storage, dropping to 83% at 16 weeks, and remaining in this range for the remainder of the storage period. Statistically these losses were nonsignificant. After 3 days of aging at 30° F. the retention at 8 weeks was 81%, dropping to 80% at 16 weeks. Losses throughout the 48-week storage period were very highly significant ($P < 0.001$). The same was true for loins aged 7 days at 30° F. with 82% retention at 8 weeks, ranging from 81 to 88% for the other storage periods. After aging 7 days at 40° F. the retention at 8 weeks of this vitamin was 87% and remained about the same as the retention for the storage periods for aging at 30° F. These variations in temperature had little effect on riboflavin changes in the loins. No significant variation which could be attributed to yearly differences was found.

Pantothenic Acid. The pantothenic acid content of the pork loins is shown in Table II. Different treatments had no effect on the initial amount of this vitamin, as the samples contained on the average 14 to 16 γ per gram for all treatments. There were some differences due

to storage after the different treatments. Aging 1 day at 30° F. allowed 81% retention of pantothenic acid after 8-week storage, decreasing to 75% retention at 16 weeks, and varying between 81 and 88% for the other storage periods. The losses over the 48-week storage period were significant ($P < 0.05$). After 3 days of aging the retention following 8 weeks of storage was 88%, with some increase in retention on longer storage. The losses for the entire period were nonsignificant. Longer aging and 10° difference in temperature had no significant effects upon the retention of this vitamin in the meat. This vitamin showed no significant differences which could be attributed to year to year variation.

Nicotinic Acid. Table II shows the nicotinic acid content of the pork. Loins aged 1 day at 30° F. contained larger quantities of this vitamin (224 γ per gram) than those aged 3 days (192 γ per gram), and those aged 7 days (175 γ per gram). The losses after storage were greater in those aged 1 day than in those aged 3 and 7 days, as the retention was 91% after 8-week, and 85% after 16-week storage and within that range for the remainder of the storage period. For the other aging periods, temperature and length of storage had little or no effect on the content of this vitamin. The loss of nicotinic acid was comparatively small during storage. The year to year differences were very highly significant ($P < 0.001$) for the loins aged 7 days at 40° F. but nonsignificant for the other aging periods.

Table II. Vitamin Content of Pork

(Average of 12 loins, stored at 0° F.)

Weeks	0	8	16	24	32	40	48
Thiamine							
Aged 1 day at 30° F.							
Av. γ/g.	75	69	65	63	63	65	65
Av. % retention		92	87	84	84	87	87
Aged 3 days at 30° F.[a]							
Av. γ/g.	86	70	64	57	65	61	68
Av. retention		81	74	66	76	71	79
Aged 7 days at 30° F.							
Av. γ/g.	79	76	67	67	67	63	72
Av. % retention		96	85	85	85	80	91
Aged 7 days at 40° F.							
Av. γ/g.	81	72	67	74	75	81	74
Av. % retention		89	83	91	93	100	91
Riboflavin							
Aged 1 day at 30° F.							
Av. γ/g.	7.8	6.9	6.5	7.0	6.6	7.2	6.7
Av. % retention		88	83	90	85	92	86
Aged 3 days at 30° F.[a]							
Av. γ/g.	8.1	6.6	6.5	6.6	6.5	6.7	7.0
Av. % retention		81	80	81	80	83	86
Aged 7 days at 30° F.							
Av. γ/g.	8.5	7.0	7.3	7.1	6.9	7.2	7.5
Av. % retention		82	86	84	81	85	88
Aged 7 days at 40° F.							
Av. γ/g.	8.4	7.3	7.4	7.2	6.2	7.3	7.2
Av. % retention		87	88	86	74	87	86
Pantothenic Acid							
Aged 1 day at 30° F.[b]							
Av. γ/g.	16	13	12	14	13	14	14
Av. % retention		81	75	88	81	88	88
Aged 3 days at 30° F.							
Av. γ/g.	16	14	14	15	14	15	15
Av. % retention		88	88	94	88	94	94
Aged 7 days at 30° F.							
Av. γ/g.	14	13	13	14	14	14	14
Av. % retention		93	93	100	100	100	100
Aged 7 days at 40° F.							
Av. γ/g.	15	14	14	14	14	14	14
Av. % retention		93	93	93	93	93	93
Nicotinic Acid							
Aged 1 day at 30° F.							
Av. γ/g.	224	203	189	194	183	213	211
Av. % retention		91	84	87	82	95	94
Aged 3 days at 30° F.							
Av. γ/g.	192	188	190	185	188	205	205
Av. % retention		98	99	96	98	107	107
Aged 7 days at 30° F.							
Av. γ/g.	175	178	178	176	183	199	196
Av. % retention		102	102	101	105	114	112
Aged 7 days at 40° F.							
Av. γ/g.	176	168	168	170	166	183	189
Av. % retention		95	95	97	94	104	107

[a] Analysis of variance very highly significant losses ($P < 0.001$).
[b] Significant losses ($P < 0.05$)

Summary

A study of the effects of aging pork carcasses from 1, 3, and 7 days at 30° F. and 7 days at 40° F. on the thiamine, riboflavin, pantothenic acid, and nicotinic acid content of the meat, including the effect of frozen storage after the different treatments, indicates that regardless of treatment before storage, animals slaughtered in January had more thiamine in the rib-eye muscle than those slaughtered in June. No seasonal differences in riboflavin content were found. Animals slaughtered in June had more pantothenic acid and nicotinic acid in the rib-eye muscle than those slaughtered in January.

In loins stored up to 48 weeks, thiamine and riboflavin showed the greatest storage losses in those aged 3 days at 30° F. They lost 20% of thiamine after 8-week storage, increasing to 33% after 24-week storage and 18% riboflavin after 8 weeks and 20% after 32 weeks. Pantothenic and nicotinic acids showed the greatest losses in storage in loins aged 1 day at 30° F. The pantothenic acid losses were 18% at 8 weeks and 24% at 16 weeks. Losses of nicotinic acid were the least of any of the vitamins, 9% at 8 weeks and 18% at 32 weeks.

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