THE THIAMIN CONTENT OF

MEATS AND CEREALS

By

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INTRODUCTION

Thiamin or Vitamin B_1 is one of the best known of the vitamins needed in our diet. Its importance is recognized universally. The Committee on Foods and Nutrition of the National Research Council (Washington) (1941) recommends a daily intake of 1.8 mg. for men and 1.5 mg. for women. The Canadian Council on Nutrition also approves these recommendations. Common sources of this vitamin are yeast, pork, liver, organs and muscles of many animals, nuts, eggs, legumes, whole grains and most vegetables. Thiamin is found in greatest amounts in yeasts, meats, cereal foods, and legumes. A tabulation of thiamin in foods in the average American diet reveals both cereals and meats supply one-quarter, dairy products and vegetables each one-fifth, and fruits one-tenth of the thiamin. The principal sources of thiamin in the average diet are lean pork, milk and bread. This was determined by Lane, Johnson and Williams (1942) using the food consumption study records of Stiebeling and Phipard (1939).

According to dietary surveys carried on under the Department of Pensions and National Health, in larger Canadian cities, thiamin is the vitamin most lacking in the diet of the average Canadian. Improvement would come with more careful food selection on the part of the consumer. This condition would be helped if food processing companies were to give more explicit information on the amounts of the nutritionally important ingredients, in terms of the daily requirement, in the products they market.

Breakfast cereals may be a worthwhile source of thiamin. The variety on the Canadian market is extensive. Advertising has popularized many types whose thiamin content is as variable as the different methods of processing employed. In many cases cereals may be stored a considerable time before consumption. This might affect their thiamin content. So might any cooking necessary to prepare them for consumption. It appeared worthwhile to determine the value of breakfast cereals as sources of thiamin and the effect of storage and cooking on them.

It is known that the thiamin content of various meats shows considerable variation. The purpose of this study is to illustrate the variation between meats of different animals as well as the variations in thiamin content within a single carcass. A wide variety of meats available and popular in Manitoba retail markets was selected for this purpose. It was decided to determine the thiamin content of an average serving of meat as served, excluding all waste and visible fat. In order that the housewife might be able to select meats which contain less waste the percent of meat originally purchased which is actually edible, was to be calculated.

Review of Literature

In 1914 Dr. Casimir Funk theorized that beriberi, scurvy and pellagra were caused by absence from the diet of special substances of the nature of organic bases which he called "vitamines". The beriberi "vitamine" he believed to be a pyrimidine base analogous with thymine. Jansen and Donath (1926) isolated the vitamin as a crystalline hydrochloride. The composition was determined by Windaus and his co-workers (1932) who gave it the formula $C_{12} H_{17} N_4 OS$. Windaus, Tschesche and Grewe

(1935) established its chemical constitution. Cline, Williams, and Finkelstein (1937) succeeded in synthesizing the vitamin, to which the name thiamin has been given.

A variety of methods for determining amounts of thiamin in food have been used, both before and after the chemical nature of the vitamin was established. Osborne and Mendel (1926) utilized the rat growth method to indicate the strength of concentrates added to an adequate diet. The rats are maintained on a thiamin deficient diet until depleted, and then given daily, weighed quantities of test material. Subsequent gain in weight is a measure of the thiamin content of the test material. The rat curative method devised later has proved to be more specific. In this method rats are maintained on a thiamin-free diet until they show declining weight, symptoms of paralysis, or both. Samples to be assayed for thiamin are adminstered orally or by injection. The length of time before a recurrence of the symptoms is noted indicates the potency of the sample in thiamin.

In England Carter and Drury (1929) observed a condition of bradycardia preceding symptoms of polyneuritis in pigeons fed polished rice. The low rate of heart beat which was due to accumulation of excess lactic acid, was increased to normal and the lactic acid disposed of by administration of thiamin. The rate of recovery to normal forms the basis of the bradycardia method of thiamin assay.

Microbiological methods for the thiamin assay of foods have been described and used to quite an extent. Orr-Ewing and Reader (1928) assayed antineuritic extracts by growth promoting tests on Streptothrix corallinus. Schopfer (1935) found the growth of Phycomyces blakesleeanus sensitive to the presence of thiamin, others have not considered this test specific so it has not been used extensively. The yeast fermentation method of Schultz, Atkin and Frey (1937) is the most widely used microbiological method today. In this method the influence on rate of gas production of test materials is compared with that of standard thiamin solutions. The greater the concentration of thiamin, the greater is the increase in gas production.

A new chemical method of measuring thiamin was developed by Kinnersley and Peters (1938). In 1935 they reported that one of the most nearly pure preparations of thiamin available was converted by oxidation in aqueous solution into a substance showing intense sky blue fluorescence. Kuhn, Wagner-Jauregg, van Klaveren and Vetter (1935) gave the name "thiochrome" to the sky blue fluorescence in ultra violet light produced when thiamin is subjected to mild oxidation as by alkaline potassium ferricyanide. It has been shown that the intensity of fluorescence is proportional to the concentration of thiochrome and therefore to the concentration of thiamin from which it is formed by oxidation. Several modifications of this method have been reported. One of these modifications is that of Hennessy and Cerecedo (1939). Two modifications of the Hennessy and Cerecedo method were used in this laboratory for the analysis of cereals and meats.

Both biological and chemical methods have been used to determine the thiamin content of a variety of foods. Less information has been published for breakfast cereals than for meats.

Nordgren and Andrews (1941) found that the thiamin content of wheat is influenced by the type, variety and environment during growth of the wheat. Durum and spring wheats have the highest thiamin content followed by hard winter and soft varieties. The same variety of wheat grown in different locations frequently differs in thiamin content. So breakfast cereals from the same variety of wheat grown and packaged in different sections of Canada or in Canada and the United States, might vary widely in thiamin content. Golberg and Thorpe (1942), on analysis of samples of South African wheat, discovered that varieties of wheat grown on irrigated land were 15% higher in thiamin than similar varieties grown on swamp land. The use of potassium and nitrogen fertilizers caused an increase in thiamin content. When water, manure, and phosphorus fertilizers were used thiamin content increased from 264 mcg./100 gm. to 336 mcg./100 gm.

Allen (1943) in New Zealand found variations in cereal foods from packet to packet according to age, storage conditions and thiamin content of the grain. This was the first indication that the value for a particular cereal product cannot be considered universal. A study of thiamin content of various parts of the grain by Geddes and Levine (1942) showed that thiamin is transferred from the stem to the leaf, glume and rachis. There are at the same time changes in the thiamin content of the different parts of the seed. Thus the degree of maturation and portion of the grain used would determine the thiamin content of the cereal product.

The thiochrome method was used by Slater and Rial (1942) for the analysis of Australian biscuits and breakfast foods. Brand names were not given and soft Australian wheat is not of the same thiamin content as Canadian hard wheat, so that results are not comparable. Jackson and Malone (1943) in Canada have reported on breakfast cereals as have Kitzes and Elvehjem (1943,1944) in the United States. The following are typical of the values they found, the results being reported as, or calculated by us to, mcg./gm.

	Allen (1943)	Slater and Rial (1942)	Jackson and Malone (1943)	Kitzes and Elvehjem (1943)
Bran Flakes	3.55	3.9	1.38 - 2.44	4.6 - 5.5 *
Corn Flakes			0.00 - 0.13	4.0 - 4.5 *
Oatmeal	4.32- 4.55	1.32 - 5.9	6.13 - 7.51	5.8 -15.0
Puffed Rice	negligible		0	15.0 *
Puffed Wheat			0	5.4 *
Shredded Wheat			1.83 - 3.24	1.6 - 2.4
Wheat Flakes			1.18 - 2.87	0.8

The American values marked with asterisks represent cereals fortified with thiamin concentrates and therefore are not comparable with those of other countries. Fixsen and Roscoe (1940) in England report the thiamin content of oatmeal to be 9.75 mcg./gm. they used the rat growth method of assay. These results suggest that there are marked differences between the thiamin contents of different breakfast cereals and between different samples of the same kind of cereal. A recent study of cooking losses of thiamin in breakfast cereals as related to pH values has been made by Lincoln, Hove and Harrel (1944). They found that cooking losses increased at higher pH values.

Several investigators have reported on the thiamin content of different basic cuts of meat. Values found are presented below on a wet basis as micrograms per gram of meat:

	Hiltz et al (1943)	Bacharach (1942)	Schweigert et al(1943)	Lane et al(1942)	Miller et al (1943)	McIntire et al (1944)	Reedman et al (1943)	Cover et al (1944)
Pork loin chops	5.34-8.67			14.84			419-52.0	
Pork loin roasts	6.10-7.78	0.6-0.84	7.4-15.2		9.5-23.1			
Pork shoulder roast					7.9-17.3			
Luncheon meat	2.26-4.71						* 9.6-20.7	

Continued

	Hiltz et al(1943)	Bacharach (1942)	Schweigert et al(1943)	Lane et al(1942)	Miller et al (1943)	McIntire et al (1944)	Reedman et al (1943)	Cover et al (1944)
Bacon	3.51-5.26							
Chicken		0.6-1.02						
Lamb		2.7-4.2	1.28-2.32					
Ham	5.52-8.20	0.6-1.02	7.7-14.8	11.81	10.3-23.9			
Beef rare								0.7-1.1
" well done								0.5-0.9
Liver beef						2.3		
" baby beef						1.9		
Veal heart						4.0		
Veal			1.35-2.0					

*moisture - free basis % moisture in fresh sample ranged from 57.1 - 64.8 (mean)

There are variations in the thiamin content for individual basic cuts. Miller, Rence, Dutcher, Ziegler and McLarty (1943) found that the thiamin content of pork may be directly influenced by the level of thiamin intake of the pig and suggested thiamin high feed for the hog dietary.

Schweigert, McIntire and Elvehjem (1943, 1943a) have also presented data on cooking losses. They found these losses varied with the size of the cut and cooking method used. Braising losses were greater than those for roasting or broiling, due to the extraction of thiamin by the cooking water.

Hiltz, Robinson and Levinson (1943) found cooking losses for pork to vary from 7 to over 50%. They used paired cuts in their study. They suggest that adjacent cuts might be better standards for comparison in estimating cooking losses.

Bacharach (1942) suggested that further analyses of meats should present values as consumed, rather than as gathered, slaughtered or purchased. The study of causes of variation from breed to breed or within the breed or within the carcass of a single animal, was also recommended.

PART A CEREALS

M E T H O D S

Samples of varieties of breakfast cereals available on the Winnipeg market were purchased for analysis. Ready - to - eat cereals were analysed as purchased and uncooked or partially cooked varieties were cooked according to the manufacturers directions as outlined on the package. For rolled oats the two steps referred to in Table III is the overnight method of cereal cooking. Cereal was added to rapidly boiling water and cooked over direct heat five minutes. It was then covered and cooked twenty-five minutes the next morning over a double boiler. Uncooked cereals were ground and analysed in duplicate for moisture content by the vacuum oven method. Similarly the moisture content of cooked cereals was determined.

After the first sampling the packages were sealed and stored at room temperature for one year. Some packages were stored without preliminary analysis. Then samples were ground and tested for moisture and thiamin. The analyses before storage were made by Miss Abigail Levinson. Those after storage were made by the author. The same methods for breakfast cereals were used by both investigators.

As stated previously the method used for thiamin determination was that of Hennessy and Cerecedo with slight modifications. The details of the method were:- Duplicate five gm. samples of ground cereal was mixed with about 90 cc. of 2% acetic acid solution in an Erlenmeyer flask, shaken thoroughly and placed in a boiling water bath for one hour. Then the flask was cooled. To it was added 2 cc. of 36% sodium acetate solution to bring the pH to 4.0 to 4.5. This was checked with bromcresol green on the spot plate. 0.4 gm. takadiastase in 2 cc. water were added and the mixture incubated for two hours at 50° C with occasional shaking 1 cc. of normal sulfuric acid solution was added and the mixture brought to a boil. Then it was cooled and made up to 100 cc. in a volumetric flask. A portion was centrifuged, 20 cc. of the extract was heated to boiling and allowed to seep through a column of activated 60-80 mesh Decalso in a base exchange tube. The liquid was passed through the column a second time. The Decalso absorbed the thiamin and so separated it from the extract. It was removed from the Decalso by passing boiling 25% potassium chloride solution through the column. The eluate was made up to 25 cc. A 5 cc. aliquot was placed in a reaction vessel. To it was added 3 cc. of a mixed reagent made by diluting 1 cc. of 3% potassium ferricyanide solution to 100 cc. with 15% sodium hydroxide solution. After one minute 16 cc. of isobutyl alcohol were added and the reaction vessel shaken vigorously for one and a half minutes. It was next centrifuged at low speed for 45 seconds. The water layer was drawn off. 1.5 gm. of anhydrous sodium sulfate was shaken with the isobutyl alcohol layer for twenty seconds. The layer was then poured off into a cuvette. This was placed in a Coleman Electronic Photofluorometer, model twelve, and the reading taken. A blank was run using 5 cc. of the eluate but adding 3 cc. of 15% sodium hydroxide instead of the mixed reagent. The difference between the readings for the sample and that for the blank is a direct measure of the amount of thiamin in the sample. The apparatus was calibrated by the use of thiamin.

Each result reported is the average of two determinations. Most of these checked within one division on the photofluorometer scale - in terms of thiamin this is within 0.03 micrograms per gram. It represents a difference of from zero to 6% of the total thiamin in the material being tested. Duplicate results showing differences of 10% or more were discarded.

A standard thiamin solution was prepared in this laboratory. It was checked against a commercial standard - Winthrop's Vitamin B_1 standard - and against a solution provided by Dr. Hoffer of the Western Canada Flour Mills Co. Ltd. It checked with each of these outside standards.

The results are reported as micrograms of thiamin per gram of material, and are calculated to two places of decimals. For cooked cereals, the results are calculated to three places of decimals. Since the content of solids in a cooked cereal is quite low - usually about 20% - the third place of decimals is of the same order of accuracy as the second place is for uncooked cereals.

A rapid method has been proposed by Andrews and Nordgren (1941). Hoffer, Alcock and Geddes (1943) have modified this as follows:- One gm. ground cereal is weighed into a centrifuge tube and to this is added 20 cc. of 25% KCl in 2% acetic acid. The tube is swirled rapidly to disperse lumps. It is next covered with a boiling tube and set in a water bath at 70° C. for half an hour. Then it is centrifuged for five minutes at high speed. A suitable aliquot is taken for oxidation. This is performed as in the Hennessy and Cerecedo method. Readings are made with the Photofluorometer.

This rapid method eliminates digestion with amylase, which is designed to change phosphoryllated thiamin or cocarboxylase to free thiamin. Therefore the method does not account for thiamin in the bound form. Hoffer, Alcock and Geddes found their method satisfactory for wheat flour, which does not contain cocarboxylase, but did not find it adequate for wheat germ which does.

Since the conventional method is somewhat time consuming it was decided to use this one as well for breakfast cereals and to compare the results obtained with both. This short method was used only after the storage period.

<u>Results and Discussion</u>

The results of the analyses of prepared cereals for moisture and thiamin are presented in Table I. The results for the analyses of those cereals requiring cooking are presented in Table II. Data in each table include assays before

TABLE I

Thiamin Content of Prepared Cereals

		Newly Purchased			After Storage			
			Thiamin (Long Method)			Thiamin(Wet Basis)		Thiamin(Dry Basis)
						(Long Method)	(Short Method)	(Long Method)
		Moisture %	(Wet Basis) Mcg./gm.	(Dry Basis) Mcg./gm.	Moisture %	Mcg./gm.	Mcg./gm.	Mcg./gm.
oducts derived largely from wheat:								
Bran Flakes	1	6.52	2.98	3.19	12.28	2.94	0.65	3.35
Bran Flakes	2a	6.07	1.51	1.61				
Bran Flakes	2b				11.76	2.68	1.22	3.03
Bran Flakes	2c				11.13	2.43	1.34	2.73
Bran Flakes	3	5.00	2.46	2.59	12.19	2.38	1.91	2.71
Bran Flakes	4a	5.48	2.61	2.76	12.88	1.94		2.23
Bran Flakes	4b				12.84		1.44	
Whole Wheat	1	5.41	1.84	1.95	11.75	1.82	0.41	2.06
Whole Wheat	2	5.69	0.63	0.67	9.61	0.73	0.32	0.81
Whole Wheat	3	6.48	2.05	2.19	7.03	1.94	0.83	2.09
Whole Wheat	4	4.25	3.07	3.31	8.59	3.56	0.64	3.89
Whole Wheat	5	4.95	2.73	2.87	9.39	3.44	1.73	3.80
Shredded Wheat	1	6.69	2.28	2.44	9.52	2.37	1.72	2.62
Shredded Wheat	2	4.81	2.25	2.36	9.11	1.10	1.05	1.21
Puffed Wheat	1	5.74	0.09	0.10	8.35	0.14	0.11	0.15
Puffed Wheat	2a	7.61	0.16	0.17	8.99	0.08	0.04	0.09
Puffed Wheat	2b				7.61	0.25	0.22	0.27
Wheat Germ	1a	7.67	27.49	29.77	9.93	23.20	4.98	25.76
Wheat Germ	1b				10.63	18.37	2.02	20.55
Products derived largely from Corn:								
Corn Flakes	1	5.07	0.24	0.25	6.34	0.30	0.07	0.32
Corn Flakes	2	5.17	0.47	0.50	11.59	0.90	0.10	1.02
Corn Flakes	3	4.65	0.55	0.58	8.40	0.18	0.15	0.20
Corn Flakes	4a	5.43	0.32	0.34	11.81		0.29	
Corn Flakes	4b				11.17	0.14	0.07	0.16
Corn Flakes	4c				11.33	0.33	0.16	0.37
Puffed Corn	1	6.84	0.16	0.17	11.20	0.17	0.09	0.19
Puffed Corn	2	722	0.35	0.38	4.87	0.09	0.21	0.09
Products derived largely from Rice:								
Puffed Rice	1	7.48	0.23	0.25				
Puffed Rice	2	6.54	0.46	0.49	11.40	0.15	0.29	0.17
Puffed Rice	3a	5.68	0.20	0.21	12.02	0.27	0.21	0.31
Puffed Rice	3b				11.55		0.09	
Products not otherwise classified:								
Puffed Wheat and Rice		7.46	0.18	0.19	12.12	0.28	0.11	0.32
Wheat and Oat flakes		5.30	3.94	4.16	9.62	2.55	1.88	2.82
Mixed Cereals		5.14	2.67	2.18	9.27	1.94	0.12	2.14

DATA IN COLUMNS 1, 2, AND 3 ARE FROM ASSAYS OF A.R. LEVINSON 1942 - 3.

TABLE II

Thiamin Content of Cooked Cereals

		Newly Purchased			After Storage			
		Moisture %	Thiamin (Long Method) Wet Basis Mcg./gm.	Thiamin (Long Method) Dry Basis Mcg./gm.	Moisture %	Thiamin (Wet Basis) (Long Method) Mcg./gm.	Thiamin (Wet Basis) (Short Method) Mcg./gm.	Thiamin (Dry Basis) (Long Method) Mcg./gm.
Products derived largely from Wheat:								
Whole Wheat	Uncooked	12.68	4.07	4.66				
	Cooked	84.23	0.764					
Wheat Farina 1	Uncooked	9.25	0.66	0.73	12.48	0.35	0.42	0.40
	Cooked	82.32	0.119		87.16	0.153		
Wheat Farina 2a	Uncooked	8.72	0.48	0.53	11.67	0.41	0.25	0.46
	Cooked	80.77	0.092		87.62	0.092		
Wheat Farina 2b	Uncooked				13.56	0.93	0.66	1.08
	Cooked				87.77	0.238		
Products derived largely from oats:								
Rolled Oats 1	Uncooked	7.28	6.59	7.11	11.28	3.84		4.33
	Cooked 1 step	84.97	1.038		77.93	0.818		
	Cooked 2 steps	84.61	1.028					
Rolled Oats 2	Uncooked	8.00	3.98	4.33	7.54	3.89	0.24	4.21
	Cooked	80.42	1.519		77.90	0.755		
Rolled Oats 3a	Uncooked	7.85	4.94	5.36	6.08	5.56	2.38	5.92
	Cooked	82.34	1.190		84.33	0.902		
Rolled Oats 3b	Uncooked				8.48	5.74	1.19	6.27
	Cooked				87.56	1.043		
Products derived largely from barley:								
Barley Farina	Uncooked	9.27	1.77	1.95	14.46	1.77	1.55	2.07
	Cooked	85.04	0.260		91.56	0.118		
Products not otherwise classified:								
Mixed Cereals 1	Uncooked	7.77	4.52	4.90	8.90	4.46	2.32	4.90
	Cooked	72.03	1.107		81.50	0.890		
Mixed Cereals 2	Uncooked	7.92	13.43	14.59	13.54	5.49	2.50	6.35
	Cooked	92.28	0.934		91.26	0.498		
Mixed Cereals 3	Uncooked	8.14	4.28	4.66	6.00	3.23	0.42	3.44
	Cooked	70.72	1.277		77.63	0.744		
Mixed Cereals 4	Uncooked	8.42	4.38	4.78	9.60	4.39	3.18	4.86
	Cooked	74.06	1.009		84.50	0.448		
Mixed Cereals 5	Uncooked	7.95	5.50	5.98	7.93	3.14	4.92	3.41
	Cooked	77.88	0.893		78.52	0.647		
Mixed Cereals 6	Uncooked	9.07	3.80	4.18	10.35	1.82	2.51	2.03
	Cooked	81.20	0.637		82.71	0.363		
Mixed Cereals 7	Uncooked	9.37	4.67	5.15	11.33	3.44	3.98	3.88
	Cooked	76.93	0.858		36.87	0.729		

DATA IN COLUMNS 1, 2 AND 3 ARE FROM ASSAYS OF A.R. LEVINSON 1942 - 3.

and after storage, and in Table II before and after cooking. Cereals are described according to their common characteristics and according to the grain from which they are made rather than their trade names. Where several results are reported for one variety of cereal each result is for a separate package of the cereal. These are distinguished by the use of the small letters a, b and c.

The amount of thiamin in an average serving of each of these cereals is shown in Table III. For most prepared cereals a cup was considered an average serving. For prepared cereals in biscuit form a single biscuit was weighed. The portion of wheat germ weighed was one tablespoon. For cooked cereals this weight was determined by weighing three fourths of a cup of cooked cereal which was taken as 180 grams for the cooked cereals in this study.

The amount of thiamin in an average serving was calculated for the newly purchased cereals only. In each case thiamin content as determined by the standard long method was used in calculation.

TABLE III

Thiamin Content of Average Servings of Breakfast Cereals

		Average Serving gm.	Thiamin in Average Serving mcg.
Prepared Cereals:			
Bran Flakes	1	50	149
Bran Flakes	2a	50	76
Bran Flakes	3	50	123
Bran Flakes	4	50	131
Whole Wheat	1	30	55
Whole Wheat	2	28	18
Whole Wheat	3	18	37
Whole Wheat	4	60	184
Whole Wheat	5	40	109
Shredded Wheat	1	28	64
Shredded Wheat	2	28	63
Puffed Wheat	1	15	1
Puffed Wheat	2	15	3
Wheat Germ		7	192
Corn Flakes	1	25	6
Corn Flakes	2	25	12
Corn Flakes	3	25	14
Corn Flakes	4a	25	8
Puffed Corn	1	15	3
Puffed Corn	2	15	5
Puffed Rice	1	15	4
Puffed Rice	2	15	7
Puffed Rice	3a	30	6
Puffed Wheat and Rice		15	3
Wheat and Oat Flakes		60	236
Mixed Cereals		25	67
Cereals Requiring Cooking:			
Whole Wheat		180	138
Wheat Farina	1	180	21
Wheat Farina	2	180	17
Rolled Oats 1 Cooked one step		180	187
Rolled Oats 1 Cooked two steps		180	185
Rolled Oats	2	180	273
Rolled Oats	3a	180	214
Barley Farina		180	47
Mixed Cereals	1	180	199
Mixed Cereals	2	180	168
Mixed Cereals	3	180	230
Mixed Cereals	4	180	182
Mixed Cereals	5	180	161
Mixed Cereals	6	180	95
Mixed Cereals	7	180	174

The effect of cooking is shown in Table IV. The thiamin contents of cooked and uncooked samples are calculated to a dry basis to facilitate their comparison. The cooking time required for each cereal is included in the Table.

A comparison of the results obtained by the methods of Hennessy and Gerecedo (1939) and of Hoffer, Alcock and Geddes (1943) shows in general that the shorter method gives lower results than the longer one. It would appear that the method of Hoffer, Alcock and Geddes cannot be used as a replacement for the longer one for substances of as diverse composition as breakfast cereals. Therefore we have considered only the results obtained with the standard method involving digestion with amylase.

The thiamin contents of the cereals analysed are of the same order as those reported by other investigators. Those derived largely from corn and rice are quite low in thiamin. Higher values doubtless would have been obtained for rice preparations if the rice bran had been retained in the cereal. The products derived largely from wheat endosperm, which is

TABLE IV

Thiamin Loss in Cooking Breakfast Cereals

		Cooking Time Min.	Thiamin (Dry Basis) Mcg./gm.			
			Uncooked Cereal	Cooked Cereal	Cooking Loss	Thiamin Loss %
Whole Wheat		5	4.66	4.84	-----	----
Wheat Farina 1		3	0.73	0.67	0.04	5.5
Wheat Farina 1	Stored	3	0.40	1.19	----	----
Wheat Farina 2		45	0.53	0.48	0.05	9.5
Wheat Farina 2	Stored	45	0.46	0.74	----	----
			1.08	1.95	----	
Rolled Oats 1	Cooked 1 step	30	7.11	6.91	0.20	3.6
Rolled Oats 1	Cooked 2 steps	30	7.11	6.68	0.43	6.8
Rolled Oats 1	Stored	30	4.33	3.71	0.62	14.3
Rolled Oats 2	Stored	2½	4.21	3.42	0.79	18.8
Rolled Oats 2		2½	4.33	7.76	----	----
Rolled Oats 3		7	5.36	6.74	----	----
Rolled Oats 3	Stored	7	5.92	5.76	0.16	2.7
			6.27	8.38	----	----
Barley Farina		3	1.95	1.74	0.21	10.8
Barley Farina	Stored	3	2.07	1.40	0.67	32.4
Mixed Cereals 1		3	4.90	3.96	0.94	19.2
Mixed Cereals 1	Stored	3	4.90	4.81	0.09	1.8
Mixed Cereals 2		3	14.59	12.10	2.49	17.7
Mixed Cereals 2	Stored	3	6.35	5.70	0.65	10.2
Mixed Cereals 3		3	4.66	4.36	0.30	6.4
Mixed Cereals 3	Stored	3	3.44	3.33	0.11	3.2
Mixed Cereals 4		20	4.78	3.89	0.89	18.6
Mixed Cereals 4	Stored	20	4.86	2.83	2.03	41.8
Mixed Cereals 5		25	5.98	4.04	1.94	32.4
Mixed Cereals 5	Stored	25	3.41	3.01	0.30	8.9
Mixed Cereals 6		25	4.18	3.39	0.79	18.9
Mixed Cereals 6	Stored	25	2.03	2.10	----	----
Mixed Cereals 7		15	5.15	3.72	1.43	27.8
Mixed Cereals 7	Stored	15	3.88	1.15	2.73	70.4

DATA FOR CEREALS PRIOR TO STORAGE FROM ASSAYS OF A.R. LEVINSON, 1942-3.

designated here as wheat farina, are likewise not particularly good sources of the vitamin. Those made from whole wheat are much better in this regard, the bran and germ of the wheat contributing substantially to the thiamin in the manufactured cereal.

Rolled oats is a better source of thiamin than whole wheat. The cereals made from mixtures of several grains appear to be as good and occasionally better sources of thiamin than oatmeal. This is no doubt because they are reinforced with wheat bran and germ or rice polishings or other thiamin concentrates. With the exception of those cereals derived largely from wheat endosperm, breakfast foods which require cooking appear to be better sources of thiamin than prepared ones. This is substantiated by the examination of the amount of thiamin in an average serving of each of these cereals.

From the data of Tables I and II it is seen that breakfast cereals retain most of their thiamin when stored at room temperature for considerable periods of time. Slight losses are evident in some cases. There are apparent gains in others.

The data of Table III indicate how much of the recommended daily allowance of thiamin for the average man may be provided by a single serving of a breakfast cereal. One brand of rolled oats contributes between 15% and 16% of this amount. Rolled oats, whole wheat and mixed cereals contribute from 10% - 15% per portion. Wheat endosperm, corn and rice products contribute very little. Cooked cereals contribute more than prepared ones. This is not explained by difference in size of portion as 180 grams of cooked cereal contain approximately the same amount of solids as an average serving of prepared cereal.

Cooking does not lower the thiamin content appreciably. Some of the rolled oats and wheat endosperm cereals show apparent gains. Mixed cereals show the greatest cooking losses. This is not surprising since they require a longer cooking period than most other cereals. While individual samples showed a higher degree of loss the majority have less than 20% of their thiamin destroyed. In half of the cases a loss of less than 10% was encountered.

PART B MEATS

M E T H O D S

The meats studied in this investigation were beef, veal, lamb, pork, variety meats and poultry. Standard household cuts were purchased for uncooked analysis. Similar adjacent cuts were purchased for cooking studies. Each cut for uncooked analysis was weighed and divided into meat, bone and visible fat, which were weighed separately. Each cooked cut was weighed before and after cooking and divided after cooking into meat, bone, visible fat and drippings, which were weighed separately. The meat alone was retained for analysis. It was ground in a meat grinder to produce a homogenous sample. Samples were taken for duplicate thiamin assays by the method outlined below and for duplicate moisture tests. In the analysis of raw samples meat was removed from the bone and weighed as were the bone and visible fat portions. The meat was put through a standard meat chopper twice. Duplicate samples were taken for thiamin and moisture assays.

Samples were cooked following standard methods of cookery for general household usage as outlined by the Committee on Preparation Factors, National Cooperative Meat Investigators (1942). Oven temperatures , internal temperatures (as shown by a Taylor Meat Thermometer at the centre of the roast) and cooking times are given in the tables showing primary data.

The cooking of roast meats was done at specified oven temperatures until the specified internal temperature was reached. Where the use of a thermometer was not feasible, meats were cooked a recommended time as specified in the above reference, the time being varied according to the weight of the cut.

The method used for thiamin analyses was a modification of the Hennessy and Cerecedo method, sample weight varied from 10 to 50 gms. The sample to be used was weighed and ground into a homogenous mass with approximately 225 cc. of 0.1N sulfuric acid solution,(this amount also varied with the weight of the sample) in the Waring Blendor. This required five minutes. The volume was made up to 300 cc. in a volumetric flask with more of the acid solution. Then it was heated for one hour at 70° C., and to it was added 1.2 gm. takadiastase in 20 cc. of 2.5 molar sodium acetate solution. The mixture was heated for one hour at 50° C. and twelve hours at 37° C. Next it was filtered and the filtrate made up to 500 cc. in a volumetric flask. An appropriate aliquot was allowed to seep through a Decalso column. From this point on the procedure was the same as that for cereals. Determinations were made on the aliquots of pure thiamin solution at the same time and the results calculated by comparing their respective readings on the photofluorometer.

Experimental Results

The primary data for beef and veal cuts are presented in Table V. This includes seven roasts which were cooked until a specified internal temperature was reached. The beef steaks were pan broiled to the medium done stage. The veal cutlets were pan broiled to a well done stage. Stewing beef of the neck roast was simmered in water to cover until tender.

The thiamin content of cooked and uncooked samples of beef and veal on a wet and dry basis is shown in Table VI. The percentage loss of thiamin on cooking is shown in the same table. Table VII presents the moisture content of both cooked and uncooked portions and the thiamin content of a 100 gram portion of cooked and uncooked beef. The percent of the as purchased (A.P.) cut actually edible after cooking is recorded. This refers to the meat, including invisible fat but not bone. drippings or visible fat. The amount of thiamin in 100 grams as purchased after cooking

TABLE V

Weight of Component Parts of Cuts of Beef and Veal in Grams

Before Cooking	Rump Roast	Prime Ribs	Rd. Bone Shoulder	Porterh. Steak	Blade Roast	Sirloin Steak	Wing Roast	Round Steak	Neck Roast	Veal Cutlets	Round Rst. Veal
Wt. Cut of Meat	1833.0	1620.0	1583.0	261.0	1612.0	507.0	1357.0	471.0	302.0	202.0	1278.0
After Cooking											
Wt. visible Fat and Drippings	389.0	391.0	546.0	47.0	402.0	77.0	434.0	77.0	20.0	29.0	203.0
Wt. of Bone	240.0	283.0	132.0	34.0	331.0	58.0	72.0	———	32.0	34.0	136.0
Wt. Cooked Meat	912.0	608.0	638.0	151.0	557.0	234.0	582.0	274.0	135.0	84.0	666.0
Total Weight	1541.0	1282.0	1316.0	232.0	1290.0	369.0	1088.0	351.0	187.0	147.0	1005.0
Moisture %	62.2	57.5	65.7	63.9	61.7	62.1	60.3	62.1	55.8	60.9	66.5
Moisture	567.1	349.3	419.1	96.5	353.7	145.1	366.2	170.1	74.5	51.1	443.1
Solids not visible fat	345.0	258.7	218.9	54.5	203.3	89.0	215.8	103.9	60.5	32.9	222.9
Cooking time min.	129	102	94	12	102	18	116	19	92	14	124
Oven Temp.°F. max.	325	325	325		325		325				320
" " min.	315	315	315		315		315				310
Internal temp.	165	165	165		165		165				170
Uncooked Meat											
Total Wt. of Cut	1467.0	1174.0	1042.0	309.5	1210.0	507.0	1179.0	438.5	378.0	166.0	1180.0
Wt. visible fat	480.0	338.0	386.0	77.0	285.0	105.0	505.0	74.0	76.0	11.0	165.0
Wt. of Bone	93.0	198.0	7.0	38.0	260.0	45.0	138.0	41.0	86.0	52.0	907.0
Wt. Fresh Meat	894.0	638.0	649.0	194.5	665.0	357.0	536.0	323.5	216.0	103.0	108.0
Moisture %	70.6	68.0	74.0	74.7	73.7	74.3	71.9	73.9	71.3	75.1	75.3
Moisture	631.2	434.1	480.5	145.3	490.2	265.1	385.5	238.0	154.0	77.4	81.3
Solids not visible fat	262.8	203.9	168.5	49.2	174.8	91.9	150.5	84.5	62.0	25.7	26.7

TABLE VI

Thiamin Content of Beef and Veal

Beef	Wet basis mcg./gm.		Dry basis mcg./gm.		Cooking Loss %
Cut	Uncooked	Cooked	Uncooked	Cooked	
Rump Roast	0.201	0.302	0.683	0.797	——
Prime Ribs	0.239	0.286	0.748	0.672	10.16
Round Bone Shoulder Roast	0.186	0.232	0.714	0.675	5.46
Porterhouse Steak	0.214	0.302	0.844	0.836	0.95
Blade Roast	0.199	0.286	0.757	0.747	1.32
Sirloin Steak	0.301	0.385	1.164	1.012	13.12
Wing Roast	0.212	0.321	0.756	0.807	——
Round Steak	0.283	0.329	1.084	0.868	19.92
Stewing Meat Neck	0.441	0.398	1.535	0.388	74.77
Veal					
Veal Cutlets	0.514	0.265	2.064	0.679	67.10
Round Roast of Veal	0.499	0.818	2.021	2.437	——

TABLE VII

Thiamin Content of One Hundred Gram (A.P.) Portions of Beef and Veal.

	UNCOOKED			COOKED		
Cut of Meat	Moisture %	Thiamin in 100 gm. A.P. Fresh basis mcg.	% A.P. Meat Edible	% Moisture	Thiamin in 100 gm. A.P. Fresh basis mcg.	% A.P. Meat Edible
Rump Roast	70.60	13.6	67.8	62.18	15.0	48.5
Prime Ribs	68.04	15.7	65.6	57.45	10.7	38.0
Round Bone Shoulder Roast	74.04	11.6	62.5	65.69	9.3	40.4
Porterhouse Steak	74.69	13.4	62.9	63.88	17.4	57.7
Blade Roast	73.72	11.2	56.2	61.70	9.9	34.5
Sirloin Steak	74.27	21.1	70.1	61.95	17.8	46.5
Wing Roast	71.92	9.4	45.5	60.29	13.7	43.1
Round Steak	73.89	20.8	73.6	62.07	19.1	58.3
Neck-Stewing Meat	71.30	26.0	57.2	55.16	17.8	45.0
Veal						
Veal Cutlets	75.10	32.2	62.7	60.88	11.1	41.6
Roast Round	75.31	38.4	76.9	66.53	43.1	52.1

All moisture and thiamin values are for 100 gm. A.P. portions, with bone and visible fat and in the case of cooked meats, drippings, removed. % edibility refers to % of meat left after removal of bone, visible fat and dripping.

is determined thus:-

$$\frac{\text{wt. of cooked meat (excl. waste)}}{\text{wt. of A.P. meat (incl. waste)}} \times 100 \times \text{mcg. thiamin in cooked meat fresh basis}$$

Thus actual thiamin content of meat as eaten is obtained rather than a general figure for thiamin content of the roast or steak as a whole. It is assumed that the thiamin content of drippings is negligible as shown by Hiltz, Robinson and Levinson (1943).

In Table VIII primary data for pork roasts and chops are presented. The roasts were cooked until the specified internal temperature was reached. Ten pork chops beginning at the shoulder were analysed. Alternate ones were panbroiled in a preheated skillet to the well done stage (average twelve minutes) and assayed in that form. The others were assayed uncooked. Micrograms of thiamin in an entire chop as served is included in this table.

In Table IX the thiamin content of cooked and uncooked samples of pork on a wet and dry basis is shown.

TABLE VIII

Weight of Component Parts of Pork Roasts and Chops in Grams

Before Cooking	Loin 1	Roast 3	Pork Chop 1	Pork Chop 3	Pork Chop 5	Pork Chop 7	Pork Chop 9
Wt. Cut of Meat	891.2	1005.2	136.3	121.8	125.9	126.0	138.0
After Cooking							
Wt. visible Fat and Drippings	281.5	258.5	40.0	29.0	35.1	34.2	43.5
Wt. of Bone	121.5	93.1	5.2		8.6	17.2	18.1
Wt. Cooked Meat	373.5	483.0	60.0	59.5	49.5	43.1	46.2
Total Weight	776.5	834.6	105.2	88.5	93.2	94.5	107.8
Moisture %	54.7	52.7	39.7	43.4	46.2	40.7	40.6
Moisture	204.4	254.5	23.8	25.8	22.9	17.5	18.7
Solids not visible fat	169.1	228.5	36.2	33.7	26.6	25.6	27.5
Cooking time-min	85	108	10	9	7	7	9
Oven temp °F Max	350	350					
Oven temp° F Min	310	310					
Internal temp	182	182					
Thiamin in entire Chop as served Mcg.			429.4	536.4	798.3	680.1	957.6
Uncooked Meat			2	4	6	8	10
Total wt. Meat	716.4	1488.5	139.7	135.5	134.9	106.5	128.9
Wt. visible fat	193.5	338.5	35.2	40.0	39.8	38.8	49.5
Wt. bone	106.0	283.5	26.5	23.5	13.6	9.1	8.2
Wt. Fresh Meat	416.0	866.5	78.2	72.0	81.5	58.0	71.2
Moisture %	64.7	66.2	66.7	60.3	56.9	61.6	63.2
Moisture	269.5	573.7	52.1	43.4	46.4	36.1	45.1
Solids not visible fat	147.0	292.8	26.1	28.6	35.1	22.5	26.2

TABLE IX

Thiamin Content of Pork

Pork

Chops - Starting at Shoulder

	Wet Basis mcg./gm. Uncooked		Cooked	Dry Basis mcg./gm. Uncooked	Cooked	Cooking Loss %
II	9.644	I	7.159	28.615	11.870	58.52
IV	8.104	III	9.014	20.433	15.915	22.11
VI	7.329	V	8.691	17.007	16.126	11.06
VIII	7.523	VII	9.634	19.565	16.244	16.97
X	10.037	IX	12.323	27.257	20.727	23.99

Pork Loin Roasts

	6.151		6.455	17.432	14.280	18.39
	7.789		8.362	23.058	17.680	23.32

The percentage loss of thiamin on cooking is given in the same table.

Table X presents the moisture content of cooked and uncooked samples of pork cuts and thiamin content of a 100 gram portion of cooked and uncooked pork. The percent of the as purchased cut actually edible after cooking is given as for beef and veal. As in the case of beef and veal the cooked portion represents 100 grams of fresh meat. The same formula is used in calculating the data as before.

Primary data for cuts of lamb assayed in this study are given in Table XI. Roasts were cooked to the specified internal temperature. Chops were panbroiled on a preheated skillet to the well done stage.

Table XII presents the thiamin content of cooked and uncooked samples of lamb on a wet and dry basis. The percentage loss of thiamin on cooking is given in this table also.

TABLE X

Thiamin Content of One Hundred Gram (A.P.) Portions of Pork

		UNCOOKED				COOKED		
Cut of Meat		Moisture %	Thiamin in 100 gm. A.P. Fresh mcg.	Edible % of A.P. Meat		Moisture %	Thiamin in 100 gm. Fresh mcg.	Edible % of A.P. Meat
Chops - Starting at shoulder								
	II	66.65	538.9	55.9	I	39.69	325.7	45.5
	IV	60.34	429.0	52.9	III	43.36	443.4	49.2
	VI	56.90	441.9	60.3	V	46.17	345.0	39.7
	VIII	61.56	413.8	54.9	VII	40.69	330.4	34.3
	X	63.18	557.6	55.6	IX	40.55	412.8	33.5
Loin Roast								
Upper Shank		64.70	357.4	58.1		54.73	309.2	47.9
Lower Shank		66.21	454.7	58.4		52.70	482.4	57.7

All moisture and thiamin values are for 100 gm. A.P. portions with bone and visible fat and in the case of cooked meats; drippings removed. % edibility refers to % of meat left after removal of bone, visible fat and drippings.

TABLE XI

Weight of Component Parts Lamb Roasts and Chops in Grams

	Hind Leg Lower	Hind Leg Upper	Neck Roast	Breast and Shank	Rib Chop first	Rib Chop last	Loin Chop first	Loin Chop last
Before Cooking								
Wt. Cut of Meat	1452.0	1881.0	1698.5	1866.0	151.0	132.8	128.5	174.5
After Cooking								
Wt. Fat and Drippings	514.2	375.5	521.2	622.0	56.5	43.0	34.5	53.0
Wt. of Bone	221.5	327.5	217.0	398.5	11.5	14.5	9.2	19.5
Wt. Cooked Meat	487.5	818.0	516.0	633.0	46.1	41.8	54.8	63.0
Total weight	1223.2	1521.0	1254.2	1653.5	114.1	99.3	98.5	135.5
Moisture %	60.6	59.8	53.09	60.2	59.4	56.7	57.5	55.1
Moisture	295.6	489.2	273.94	391.8	27.4	23.7	31.5	34.7
Solids not visible fat	191.9	328.8	242.06	241.2	18.7	18.1	23.3	28.3
Cooking time-min.	113	130	127	112	11	10	10	12
Oven temp °F. Max.	320	320	320	320				
Oven temp °F. Min.	310	310	310	310				
Internal Temp.	175	175	175	175				
Thiamin in entire Chop as served - mcg.					20.04	18.19	40.76	71.39
Uncooked Meat								
Total wt. of cut	1489.0	1788.0	1908.5	1701.5	134.3	97.8	114.5	149.0
Wt. visible fat	528.3	273.5	605.0	587.5	64.3	39.5	48.5	54.5
Wt. of Bone	203.5	329.0	387.0	361.0	23.5	9.8	5.0	16.0
Wt. Fresh Meat	757.2	1185.5	918.5	753.0	46.5	48.5	61.0	78.5
Moisture %	60.6	71.9	70.2	71.4	66.6	68.0	69.5	68.6
Moisture	459.2	852.5	644.5	537.7	31.0	33.0	42.4	53.9
Solids not visible fat	298.0	333.0	274.0	215.3	15.5	15.5	18.6	24.6

TABLE XII

Thiamin Content of Lamb

Lamb	Wet Basis mcg./gm. Uncooked	Wet Basis mcg./gm. Cooked	Dry Basis mcg./gm. Uncooked	Dry Basis mcg./gm. Cooked	Cooking Loss %
Hind Leg Lower Portion	0.502	0.569	1.895	1.470	22.43
Hind Leg Upper Shank	0.362	0.418	1.290	1.039	11.70
Neck Roast	0.177	0.190	0.593	0.406	31.53
Breast and Shank	0.213	0.371	0.745	0.931	-----
Lamb Chops					
Rib 1st	0.337	0.435	1.001	1.071	-----
Rib last	0.359	0.435	1.121	1.004	10.43
Loin	0.634	0.744	2.078	1.750	15.78
Loin	1.184	1.298	3.773	2.889	23.42

In Table XIII the moisture content of cooked and uncooked samples of lamb cuts and thiamin content of a 100 gm. portion of cooked and uncooked is given. The percent of the as purchased cut actually edible after cooking is given as for beef, veal and pork.

Primary data for fowl assayed are shown in Table XIV; they are from a variety of studies. A chicken broiler was broiled in an oven at 380° for twenty-two minutes. Chicken broiler livers were small and sufficient for uncooked assay samples only. Analyses were made of light and dark meat of the right half of a chicken roasted in an oven at 325 - 350° F. for one hour and twenty minutes. Similar analyses of the left uncooked half of the chicken were made. The right half of a stewing fowl was simmered for two hours and thirty-five minutes over moderate heat with the addition of six cups of water, and light and dark meat portions assayed. A similar assay of the left uncooked portion was made. The liquid in which the fowl was simmered was assayed to determine the amount of thiamin extracted by the cooking water.

TABLE XIII

Thiamin Content of One Hundred Gram (A.P.) Portions of Lamb

	UNCOOKED			COOKED		
Cut of Lamb	Moisture %	Thiamin in 100 gm. A.P. mcg.	% of A.P. Meat Edible	Moisture %	Thiamin in 100 gm. Fresh mcg.	% of A.P. Meat Edible
Hind Leg Lower Shank	73.50	25.3	50.4	63.64	19.1	33.7
Hind Leg Upper Shank	71.91	21.6	59.6	59.80	18.1	43.4
Neck	70.17	8.5	48.1	53.09	5.8	30.4
Front Breast and Shank	71.41	9.4	44.2	60.19	12.6	33.9
Ribs Chops First 2	66.58	16.1	47.8	59.31	13.4	30.7
Rib Chops Last 2	68.02	17.8	49.7	56.67	13.7	31.5
Loin Chops	69.51	32.3	50.9	57.49	31.4	42.2
Loin Chops	68.62	62.4	52.7	55.09	46.2	35.6

All moisture and thiamin values are for 100 gm. A.P. portions with bone and visible fat and in the case of cooked meats, drippings removed. % edibility refers to % of meat left after removal of bone, visible fat and drippings.

TABLE XIV

Weight of Component Parts Cuts of Fowl in Grams

	Chicken Broiler	C. Broiler Liver	Roast Chicken	R. Chicken Liver	Stewing Fowl	Roast Turkey	R. Tur Liver
Before Cooking							
Wt. Cut of Meat	778.0		744.0	37.0	1094.0	2198.0	62.0
After Cooking							
Wt. Fat and Drippings	50.0		18.0		148.0	218.0	
Wt. of Bone	225.0		165.0		271.0	579.0	
Wt. Cooked Meat (total light & dark)	264.0		260.0	22.0	295.0	754.0	38.0
Total Weight	539.0		443.0	22.0	714.0	1551.0	38.0
Moisture % (Av. Light & dark)	68.12		63.1	58.36	59.84	58.53	48.85
Moisture	179.84		164.0	12.84	176.53	441.32	18.56
Solids not visible fats	84.16		96.0	9.16	118.47	312.68	19.44
Cooking time min.	22		80	80	155	105	105
Oven Temp. F. Max.	380		350			350	350
Oven Temp. F. Min.	380		325			350	350
% A.P. Meat edible after cooking	33.9		33.6		26.96	34.30	
Thiamin in 100 gm. A.P. Meat after cooking(AV.L&D)mcg.	14.0		13.8		2.24	10.49	
Uncooked Meat							
Total Wt. of Cut	610.0	25.0	620.0		950.0	2054.0	
Wt. visible fat			6.0		230.0	385.0	
Wt. Bone & Skin	256.0		298.0		426.0	723.0	
Wt. Fresh Meat (total light & dark)	354.0	25.0	316.0		292.0	946.0	
Moisture % (Av. light & dark)	74	71.9	73.9		71.76	71.88	
Moisture	264.7	18.0	233.4		209.54	679.98	
Solids not visible fat	89.4	7.0	82.6		82.46	266.02	

All moisture and thiamin values are for 100 gm. A.P. portions with bone and visible fat and in the case of cooked meats; drippings removed. % edibility refers to % of meat left after removal of bone, visible fat and drippings.

The right half of a turkey was roasted in an oven at 350°F. for one hour and forty-five minutes and then assayed. The left half was assayed uncooked. Light and dark meat were analysed separately in both portions.

In Table XV the thiamin content of fowl on a dry and wet basis in cooked and uncooked samples is given. Cooking losses are also recorded in this table.

Several "variety meats" (internal organs) were analysed. Pork liver as purchased was divided in two, one half being assayed uncooked and the other after being broiled until medium done. A portion of lard weighing 5 gm. was added for broiling which required twenty minutes. Similarly beef liver was divided, cooked and assayed in the cooked and uncooked state. The cooking method was parbroiling over low heat for fifteen minutes. Lamb kidney and beef kidney were soaked one hour in cold water before parbroiling ten minutes. One half of each kidney was utilized for uncooked assay. Three baby beef hearts were assayed. One was baked in an oven at 350°F. until medium done (one hour and twenty minutes).

TABLE XV

Thiamin Content of Fowl

Cut	Wet Basis Mcg. / gm. Uncooked	Wet Basis Mcg. / gm. Cooked	Dry Basis Mcg. / gm. Uncooked	Dry Basis Mcg. / gm. Cooked	Cooking Loss %
Chicken Broiler					
Light Meat	0.256	0.360	0.993	1.159	----
Dark Meat	0.491	0.468	1.992	1.433	78.06
Liver	2.024		7.202		
Roast Chicken					
Light Meat	0.441	0.358	1.703	1.016	40.34
Dark Meat	0.625	0.463	2.364	1.199	49.28
Liver		2.033		4.882	----
Stewing Fowl					
Light Meat	0.208	0.060	0.701	0.154	78.03
Dark Meat	0.271	0.105	1.009	0.251	74.13
Cooking Liquid Mcg./cc		0.028		2.770	----
Roast Turkey					
Light Meat	0.266	0.249	0.848	0.626	26.18
Dark Meat	0.376	0.362	1.333	0.839	37.06
Liver		1.061		2.074	

Another was simmered in water to cover for one hour and forty-five minutes. The third was assayed uncooked. The hearts that were cooked were soaked in cold water for one hour before cooking. Moisture analyses were made on all samples.

The thiamin contents of variety meats, both cooked and uncooked, are presented in Table XVI. Per cent cooking losses are recorded in the same table. The thiamin contents of 100 gram A.P. portions of the fresh variety meats and of the cooked meats from these portions are reported in Table XVII.

DISCUSSION

The values obtained for the thiamin content of beef vary from 0.186 to 0.441 micrograms per gram of raw meat and from 0.232 to 0.398 for cooked meat. This is somewhat lower than those reported by Cover et al (1944) which are from 0.5 to 1.1 micrograms per gram for cooked meat. Cooking losses are not very large with the exception of the stewing beef. Here a large portion of the thiamin may have been extracted by the cooking water. Other beef cuts show cooking losses up to 20%.

TABLE XVI

Thiamin Content of Variety Meats

	Wet Basis mcg. / gm.		Dry Basis mcg. / gm.		
	Uncooked	Cooked	Uncooked	Cooked	Cooking Loss %
Pork Liver	1.188	1.319	4.197	3.298	21.42
Beef Liver	1.046	1.239	3.480	2.976	14.48
Lamb Kidney	1.491	1.872	6.940	3.323	52.12
Beef Kidney	1.982	2.075	9.104	4.921	45.95
Baby Beef Hearts	1.903	1.608 Baked 1.869 Boiled	8.166	3.918 Baked 3.022 Boiled	52.02 62.99

TABLE XVII

Thiamin Content of One Hundred Gram (A.P.) Portions of Variety Meats

Cooked samples	% Moisture	(grams) Wt. of Cut	% of A.P. Cut edible	Thiamin in 100 gms./A.P. fresh basis mcg	% A.P. Meat edible after cooking	Thiamin in 100 gm.A.P. after cooking mcg.
Cut of Meat						
Pork Liver	59.91	164.0			72.56	95.7
Beef Liver	58.37	118.0			69.91	86.6
Lamb Kidney	43.68	128.0			61.71	115.5
Beef Kidney	57.83	128.0			50.00	103.8
Baby beef hearts						
Baked	58.98	458.0			36.68	59.0
Boiled	71.67	417.0			46.41	86.7
Uncooked Samples						
Pork Liver	71.69	95.0	100.00	118.8		
Beef Liver	69.96	100.5	100.00	104.6		
Lamb Kidney	78.52	97.0	88.65	132.2		
Beef Kidney	78.23	139.0	81.42	161.4		
Baby Beef Heart	76.57	417.0	85.16	162.1		

All moisture and thiamin values are for 100 gm. A.P. portions with bone and visible fat and in the case of cooked meats; drippings removed. % edibility refers to % of meat left after removal of bone, visible fat and drippings.

Table VII reveals that the edible portion of beef varies from 34.5 to 58.3% of the fresh weight. The amount of thiamin in a 100 gram A.P. portion after cooking varies from 9.3 to 19.1 micrograms. It is accordingly not a good source of thiamin in relation to the recommended daily allowance.

The thiamin content of the beef neck is high. There is an almost regular increase in thiamin content from the shoulder to the sirloin and round sections of the beef carcass. This is illustrated in Figure 1.

The amounts of thiamin found in veal are lower than those reported by Schweigert et al (1943). The data on cooking losses are not sufficient to justify drawing conclusions at this time. The two cuts of veal examined contained more thiamin than beef, but could not be considered good sources of it.

The thiamin content of pork roasts as shown in Table IX is comparable with the values reported in the literature. The values for chops are of the same order as those for roasts, but are somewhat less than some which have been reported by other workers. Cooking losses for roasts were 18.39 and 23.32% while for chops they were from 11.06 to 23.99%, with one chop showing a loss of 58.52%.

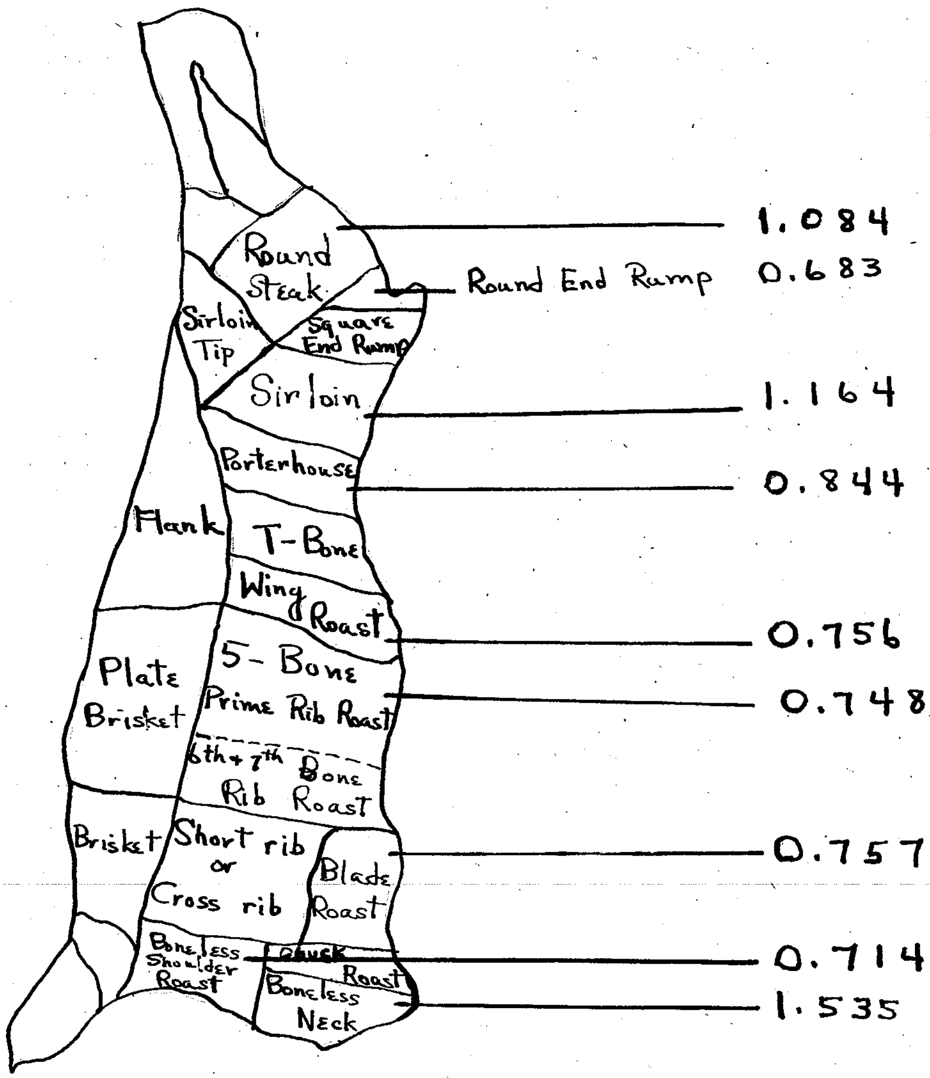
FIG.1.

Range of Thiamin Content in

Uncooked Beef Carcass

Mcg./Gm.

(Moisture Free)



In Table X it is seen that of 100 grams A.P. pork only from 33.5 to 57.7% is actually edible. This 100 gram A.P. portion when cooked contains from 309.4 to 482.4 micrograms of thiamin and indicates that this meat is a good source of the vitamin in the daily diet. This is confirmed for loin chops as shown in Table VIII. There it is seen that the thiamin content of the entire chop varies from 429.4 to 957.6 micrograms of thiamin. This latter figure is more than half of the recommended daily allowance for average adult males.

Thiamin values for cuts of lamb assayed are given in Table XII. These are lower than those reported by Bacharach (1942) and Schweigert et al (1943). Cooking losses for roasts and chops varied from 10.43 to 31.53%.

The per cent of a 100 gram fresh portion of lamb, edible after cooking, varies from 30.4 to 43.4% as shown in Table XIII. The thiamin values of this portion after cooking ranges from 12.6 to 46.2 micrograms with the value for the neck being only 5.8 micrograms.

In Table XI values for entire lamb chops as served are given. The thiamin values are from 18.19 to 71.39 micrograms or from approximately 1 to 4% of the recommended daily allowance. Compared with pork chops, lamb chops are a minor source of thiamin. The same is true for other lamb cuts.

Primary data for fowl are given in Table XIV as well as thiamin contents of one hundred gram portions of A.P. meat after cooking. Values for thiamin in these portions range from 10.48 to 14.1 micrograms, with the exception of stewing fowl the liquid of which when assayed contained considerable thiamin. The value for stewed fowl meat alone was 2.21 micrograms in the cooked meat from a one hundred gram A.P. portion.

Cooking losses as given in Table XV vary from 28.06 to 49.28% with the exception of fowl where thiamin content of cooking liquid is also given. An apparent gain of thiamin on cooking was found in the case of light meat of one broiler.

The values for dark meat are higher than those for light.

One hundred gram A.P. portions of variety meats after cooking may provide up to almost 10% of the recommended daily allowance of thiamin for the average adult male. They are then better sources of thiamin than any of the other meats studied with the exception of pork.

SUMMARY

1. Oatmeal, whole wheat cereals and those containing mixtures of many grains are highest in thiamin content of cereals analysed. Cooking losses for cereals vary but for the most part are less than 20%. After storage for one year at room temperature cereals showed little loss of thiamin.

2. The short thiochrome method of Hoffer, Alcock and Geddes which is designed for use with flour, does not determine all of the thiamin in breakfast cereals.

3. Manitoba meats contain less thiamin than is reported in the literature for the same meats in other places. The values for pork compare with the ones reported in the literature, but those for other meats are distinctly lower.

4. Beef cuts are in the lower bracket with regard to thiamin content, highest is round steak, lowest round bone shoulder roast. The beef carcass presents a gradual increase in thiamin content from shoulder to sirloin and round sections. Of meats analysed pork is highest in thiamin content but variations within a hog and even in adjacent chops are large. Thiamin content of pork roasts on an average is lower than of shoulder chops cooked and uncooked. Lamb roasts and chops have somewhat higher thiamin content than beef but are in the low range of thiamin value. Similar variations in adjacent cuts from the same animal are observed in lamb. Chops on the average are higher in thiamin than roasts. Arranged in descending order of thiamin content, meats are: Pork, Variety Meats, Fowl, Lamb, Veal and Beef.

5. Percent of the "as purchased" portion of a cut of meat which is edible (excluding visible fat) after cooking varies greatly in meats assayed. One small broiled pork chop may supply 24 - 54% of the daily requirement of thiamin for the average man. One small broiled lamb chop may supply 1 - 4% of the daily requirement of thiamin for the average man.

6. Thiamin values for dark meat of fowl are higher than those of light meat portions. Chicken livers are higher in thiamin than beef or pork liver. Turkey liver is in the range of beef or pork liver. Utilization of a considerable amount of the liquid in which fowl is simmered brings its thiamin content up to that of chicken and turkey. Thiamin content of roast chicken and chicken broilers is higher than that of fowl and turkey, as veal is higher than beef; possibly this is explained by the age of the animal.

7. Of variety meats assayed, lamb and beef kidney have the highest thiamin contents followed by baby beef hearts and pork and beef liver. All are in the upper range of thiamin content in comparison with other meats.

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