Table 4....Vitamin Content in the Drip from Beef Rib Steaks

Vitamin	Percent in Meat
Thiamine	12.2
Riboflavin	10.3
Niacin	14.5
Pyridoxin	9.4
Pantothenic Acid	33.3
Folic Acid	8.1

small block to those for quarters or cuts may be due to the volume area effect.

There are some puzzling aspects about this problem. For example, grades of beef differ in drip loss on thawing. Greater drip was found from thawed quarters of canner cattle than from higher grades. Also, different muscles exhibit variability in retaining fluid when thawed. Age of meat at time of freezing is also an important factor. Steaks cut very soon after slaughter were compared with others removed at different intervals up to five weeks. Drip was low in steaks frozen one-fourth day after slaughter, increased appreciably after one day, remained at about the same lead for five days and then decreased considerably with longer holding before freezing. In the aged meat, even though ice crystal size was large, fluid was retained on thawing.

The extent of lactic acid formation after the animal dies affects fluid-holding by the muscle. Decreased drip loss in meat was made by adjusting pH upward to about 6.3. Relating the increased drip at low pH to the isoelectric state of the muscle proteins, fast freezing decreases drip only in meat with low pH. Australian workers recently reported on extensive physiological experiments with cattle prior to killing which were aimed among other things at altering rate of lactic acid production in the carcasses. With small pieces of meat, drip loss was inversely related to pH.

Drip loss increases with length of storage. There is a variable reaction of meat to treatment and storage from animal to animal.

From the earlier discussion of effect of repeated freezing and thawing on meat structure, increased drip loss would be expected. This was shown to be the case.

Loss of Nutrients

The amount of nutrient material has been determined in the drip fluid from meat. Beef, veal, lamb and pork lose about nine percent of the total protein in this way. Later workers have been more concerned with the vitamin content of the fluid. Here the wide range reported in losses indicate large variance between animals of the same species or of different species. Pork chops lose 19 percent of their thiamine and 14 percent of their riboflavin content. On the other hand, lamb chops lost no vitamins when thawed. The vitamin content in the drip from beef rib steaks is given in Table 4.

The total vitamin loss from freezing and thawing several cuts of meat is shown in Table 5.

Different thawing methods for vitamin retention were compared. Steaks thawed in the refrigerator, at room temperature, at 163 F in water, retained the same amount of thiamine, riboflavin, and nicotinic acid. Losses of pantothenic acid did occur, and extent of loss was increased by the thawing methods in the order named.

Table 5....Vitamin Loss from Freezing and Thawing Several Cuts of Meat

Meat	Percent of Total Lost by Freezing and Thawing		
	Thiamine	Riboflavin	Niacin
Liver slices	7.0	8.3	7.0
Beef rib steaks	12.8	6.3	9.3
Rib roast	5.0	0.3	5.5
Pork chops	2.4	3.0	1.5

BIBLIOGRAPHY

A. Adajian and B. W. Gardner, Jr.: *Processed Meats, Canned Meats* (U. S. Quartermaster Food and Container Institute, Vol. 7, Part 1, 1946).

Meat and Meat Cookery (Committee on Preparation Factors, National Cooperative Meat Investigations, National Livestock and Meat Board, 1942).

Report of Food Investigations Board (Department of Scientific and Industrial Research, Great Britain, London, p. 195 1955 A).

Frozen Food Fact Book (National Frozen Food Distributors Association, New York, 1957 A).

Meat Reference Book (American Meat Institute, Chicago, 1957-58).

P. E. Bouton and A. Howard: Quality of pre-wrapped frozen meat cuts (*Food Preservation Quarterly*, Australia, Vol. 16, 1956, p. 50); (*Food Science*, Abstracts, Vol. 29, No. 114, 1957).

USDA Regulations Governing the Meat Inspection (Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D. C., 1952).

G. A. Cook et al: Studies on the refrigeration of meat—I Investigations into refrigeration of beef (Australian *Journal of Experimental Biology and Medical Science*, Vol. 3, 1926).

G. A. Fitzgerald: How to control the quality of frozen cooked foods (*Food Industry*, May 1947, p. 623).

W. A. Gortner et al: *Principles of Food Freezing* (John Wiley and Sons, New York, 1948 A).

W. Heller: Research reveals how meat shrinks (*Food Industries*, February 1942, p. 50).

E. W. Hicks: *The Evaporation of Water from Meat* (Report Food Investigations Board, Department Scientific and Industrial Research Great Britain, London, 1935, p. 19).

A. Hustrulid et al: How do fluctuating storage temperatures affect frozen foods? (REFRIGERATING ENGINEERING, January 1949, p. 38).

F. A. Lee et al: Effect of freezing rate on meat. Appearance, palatability, and vitamin content of beef (*Food Research*, Vol. 15, 1950, p. 8).

W. P. Lehrer et al: The stability of thiamine, riboflavin, and nicotinic acid of lamb chops during frozen storage and subsequent cooking (*Food Research*, Vol. 17, 1952, p. 24).

A. M. Munter and C. H. Byrne: Survey of times and temperatures in the transportation, storage, and distribution of frozen foods (*Food Technology*, September 1953, p. 356).

J. M. Ramsbottom: Meat packaging criteria. A review of recent developments in methods and materials, with new comparative test data (*Modern Packaging*, June 1954, p. 131).

J. S. Toothman: *Survey of Distribution Practices for Prepackaged Frozen Meat* (*Marketing Research Report* No. 137, USDA, Agricultural Marketing Service, 1956).

D. K. Tressler and C. F. Evers: *The Freezing Preservation of Foods*, Avi Publishing Co., Westport, Conn., 1957, 2 Vol., 3rd ed.).

B. M. Watts: Oxidative rancidity and discoloration in meat (*Advances in Food Research*, Vol. 5, 1954, p. 1).

CHAPTER 42

FROZEN POULTRY PRODUCTS

Types of Products and Methods of Preparation, Dressing and Chilling, Control of Tenderness, Packaging, Freezing Theories and Methods, Effect of Freezing on Product Quality, Freezing Methods, Quality Preservation in Storage and Marketing, Thawing and Utilization

FROZEN poultry represents a means of obtaining flexibility of operation for the producer, processor, distributor and retailer and added convenience and quality insurance for the consumer. Freezing and holding at adequately low temperatures is so far the best if not the only method of preventing all deteriorative changes and preserving the initial high quality of the freshly slaughtered bird. The commercial feasibility of certain precooked poultry items depends entirely on freezing and frozen storage.

Of the more than 6 billion pounds of poultry slaughtered annually in commercial plants, about 25 percent is frozen, the remainder being sold mainly as a chilled product. Turkeys, of which about 85 percent are frozen, make up over half of the total weight of frozen poultry. Only about 10 percent of young chickens are frozen, and 30 percent of mature chickens and 40 percent of ducks and geese. Future changes in the ratio of frozen to chilled poultry marketed will depend on the balance between several opposing economic, technological and consumption factors. Factors that favor the chilled product are lower capital investment in refrigeration facilities, lower packaging, transportation, and storage costs, enforced rapid inventory turnover, and extension of slaughtering seasons for turkeys and ducks to approach a continuous year-around operation. Shifts to the frozen product will be favored by more realistic retail marketing margins, by the increasing recognition by consumers of the excellent quality of frozen poultry products, and by the rapid expansion in production of precooked frozen poultry products such as pies and dinners. Prestuffed uncooked turkeys represent another type of product that requires marketing as a frozen product.

For discussions of processing procedures, chilling, and marketing of the chilled but unfrozen product, see Chapter 32, Poultry and Dairy Products. Some of these subjects will be discussed below, but only as they relate specifically to frozen poultry.

TYPES OF PRODUCT AND METHODS OF PREPARATION

Of the total poultry slaughtered in commercial plants in the United States, over 90 percent is marketed in a ready-to-cook or further prepared form. Of the frozen products, essentially all of the turkeys, ducks and geese are marketed in the whole form, although there is a small development in half or quarter turkeys and in deboned turkey rolls. Most of the frozen, mature chickens are sold in whole form, while frozen young chickens are marketed as whole, cut-up, and separated parts in the ratio of 2:1:2. Precooked frozen poultry products include chicken and turkey pies, roast turkey and fried chicken dinners, barbecued chicken, chicken fricassee, chicken chow mein, and chicken and turkey a la king, which are discussed in Chapter 44, Precooked and Prepared Frozen Foods.

Dressing and Chilling

Essential steps in dressing and chilling are discussed in Chapter 32, Poultry and Dairy Products. However, brief mention will be made here of those factors in the preparation phases that are essential to optimum quality and stability of the frozen product. The frozen product can be no better than the quality of the live poultry from which it is prepared. Birds should be well fleshed and well finished: also for those packaged in whole, ready-to-cook form, a premium should be placed on a pleasing compact conformation of the carcass.

Adequate bleeding and complete feather removal are essential. With the establishment of ready-to-cook poultry as the predominant marketing form, there has been a greater need to eliminate all hairs and pinfeathers on the skin surface, and a trend to produce birds with light colored plumage so that very immature nonprotruding pinfeathers will not be so noticeable.

As discussed in Chapter 32 warm evisceration (evisceration immediately after slaughter) is essential to prevent development of off flavors in the meat. Also chilling of the eviscerated carcass down to 35 F or below should be rapid in order to minimize growth of microorganisms on the skin and flesh. Growth of bacteria is substantially and effectively retarded when poultry is frozen and held at suitable temperatures.

Prevention of undue delay between slaughter and freezing will also tend to minimize dehydration and incipient rancidification. There is a minimum necessary holding time in a chilled condition above freezing for adequate tenderization to take place.

Control of Tenderness

Tenderness in cooked poultry meat is a prerequisite to acceptability and expanding consumption. It is recognized that relative tenderness decreases as birds mature and this toughness has always been taken into account in the recommendations for cooking birds of various ages. However, there is another type of toughness which depends primarily on the length of time that the carcass is held in an unfrozen state before cooking.[1] Birds cooked before they have time to pass through rigor are very tough. Normal tenderization after