Storage at 0 F or below resulted in minimum changes, even after nine months. In the results of palatability studies, it was found that storage poultry was less juicy than fresh control poultry. This condition was less serious when poultry was held at −10 F than when held at 10 F. Swanson and Sloan studied[25] chemical changes in the proteins of ready-to-cook fowl held at −5 F over a period of 40 weeks. Proteolysis was indicated during frozen storage by increases in soluble nitrogen and non-protein nitrogen of both leg and breast muscle.

The effect of variations in storage temperature on the quality of frozen turkeys was studied by Klose et al[26] for moisture losses, chemical changes, and palatability. Mature turkeys were subjected to semi-scalding and sub-scalding, three packaging materials, and storage temperatures of −30 F, −10 F, 0 F, 10 F and a fluctuating temperature condition between −10 F and 10 F. Evaluations after 6, 12 and 18 months storage indicated that, under average commercial conditions of frozen storage (moisture-impermeable package and temperature range of −10 F to 10 F), the only factor for which a periodic temperature fluctuation is inferior to the mean temperature is the accumulation of frost in the package. Frost formation, which influences appearance but not eating quality, increased with storage temperature, and for the −10 F to 10 F fluctuation was considerably greater than for the highest (10 F) constant temperature. Turkeys scalded at 140 F developed almost twice as much frost as those scalded at 126 F. Results after 12 months storage indicated a definite superiority of −10 F storage over 10 F and 0 F but no detectable organoleptic superiority of −30 F over −10 F.

During recent years, the results of many studies have been reported dealing with the development of rancidity in poultry. The influence of dietary factors, handling prior to freezing, storage temperature, and length of storage period have been given special attention.

Poultry fat will become rancid during very long storage periods or if the storage temperatures are exceedingly high. Cook and White studied[27,28] the development of rancidity in poultry fat and found that rancidity of an order that may affect quality could be obtained by holding birds five to six weeks at 32 F, followed by a 27 week storage period at 10 F or by holding poultry for 87 weeks at 10−5 F.

Wagoner, Vail, and Conrad reported[29] that holding dressed poultry at cooler temperatures for one day or longer before eviscerating and freezing decreased the stability of the poultry during storage.

Stability of poultry fat depends on its composition which in turn depends on the composition of the fat in the feed to a considerable extent. However, since most poultry feeds have about the same overall types and amount of fat, most fresh poultry fats will exhibit the same general range of composition and stability. Relative stability is conditioned primarily by two factors: content of unsaturated fatty acids and content of tocopherols. For turkeys, the presence in the feed of as little as 2 percent of a relatively unsaturated fat or oil will lead to an appreciably less stable carcass in frozen storage.[30,31] Turkeys are recognized to be less stable than chickens. However, this difference in most cases is not due primarily to differences in content of unsaturated fatty acids. Mecchi et al demonstrated[32,33] that the fatty acid composition of turkeys and chickens fed the same diet is essentially the same, and that the inherently greater stability of chicken fat compared to turkey fat is due to the greater level of tocopherol deposition effected by the chicken.

From these studies and the report[34] of Criddle and Morgan, it is clear that the stability of poultry fat, which involves prevention of oxidative rancidity, can be increased considerably with dietary supplements of the naturally occurring antioxidants, tocopherols. This is neither necessary nor economical under normal existing methods of storage. Stabilization of the highly susceptible fat in the surface layers of frozen eviscerated poultry can also be accomplished by the application of synthetic antioxidants of acceptable food grade.[35,36] Rancidity in frozen, whole, eviscerated poultry stored for as long as 12 months is, however, not a serious problem provided the bird is packaged is essentially impermeable film and held at 0 F or below. Danger of rancidification is greatly increased when poultry is cut up before freezing and storage, because of the increased surface exposed to atmospheric oxygen.

Quality losses in frozen, packaged, cut-up frying chickens were studied[37] by Klose et al over temperatures of −30 F to 20 F and storage periods from 1 month to 2 years. Comparisons were made between −30 F controls and experimental temperatures for appearance, moisture loss, peroxide development in the skin fat, *off* odors in the thawed raw meat, and *off* flavors in the cooked meat. All commercial-type samples examined were acceptable after a storage period at 0 F of at least 6 months, and some were stable for more than a year. Within reasonable storage times, a series of temperature fluctuations had the same deteriorative effect as a steady temperature equal to the mean of the fluctuations. In a comparison of a superior (moisture-vapor proof) commercial type package with a fair commercial package, increased adequacy of packaging resulted in as much extension in storage life as a decrease in storage temperature of about 20 F. The results indicate that no statement on storage life can have general value unless the packaging condition is accurately specified.

Frozen storage tests[38] by Klose et al on commercial packs of ready-to-cook ducklings and ready-to-cook geese, over a 19-month period and with steady storage temperatures covering the range from −30 to 20 F, established that these products have frozen storage lives comparable to other commercial forms of poultry. Ducks and geese should be stored at 0 F or below in order to maintain their original high quality for 8 to 12 months.

Storage studies[39] by Hanson et al on commercial and experimental packs of frozen fried chicken have indicated that the precooking produces a product much less stable than a raw product stored under the same conditions of temperature and package atmosphere. Rancidity development is the limiting factor and, surprisingly enough, it is detected in the meat slightly sooner than in the skin and fatty coating of the fried product. The marked beneficial effect of oxygen (air) free packaging was demonstrated in tests in which detectable *off* flavors were observed at 0 F in air packed samples after 2 months while nitrogen packed samples developed no *off* flavors for periods exceeding 12 months. The susceptibility of frozen fried chicken to storage deterioration indicates the need for low temperatures (0 F or −10 F) and short storage times (6 months or less) unless it is packed in an oxygen free atmosphere.

In contrast to a loosely packed product, such as the frozen fried chicken mentioned above, Hanson and Fletcher have reported[40] that a solid-pack product such as chicken and turkey pot pies, in which the cooked poultry is surrounded by sauce or gravy with consequent exclusion of air, had a storage life at 0 F of at least one year. As is the case with raw poultry, turkey products have less fat stability than do chicken products, but the stability can be increased by substitution of more stable fats in the sauces or by use of antioxidants. A quality defect found in precooked frozen products containing

a sauce or gravy is a liquid separation and curdled appearance of the sauce or gravy when thawed for use. This separation is extremely sensitive to storage temperature. Sauces can be stored at least 5 times as long at 0 F as at 10 F before separation takes place. Hanson et al established[40] that the flour in the sauce was the cause of the separation, and found among a large number of alternative thickening agents that waxy rice flour produced superior stability. Sauces and gravies prepared with waxy rice flour are completely stable for approximately a year at 0 F.

Since precooked frozen foods are not apt to be sterilized in the reheating process in the home, there is an added responsibility for the processor to keep bacterial counts in the product well below hazardous levels. Extra precautions should be taken in general plant sanitation, in rapid chilling and freezing of the cooked products, and in care that the products do not reach a temperature at any time during storage or distribution that will permit bacterial growth

THAWING AND UTILIZATION

Under ordinary conditions, it is desirable to keep the poultry frozen until shortly before it is to be consumed. The general procedure is to defrost in air or in water. Hoffert et al found[41] no significant differences in palatability between thawing in oven, refrigerator, room and water.

For turkeys that have been scalded at high temperatures and fast frozen to give a light appearance, it is especially important to keep the temperature in retail storage and display as low as possible (0 F is a reasonable goal) to prevent darkening. Darkening on thawing will be minimized by thawing in the package.

It has become common practice in some retail stores to allow frozen poultry to start thawing in the chilled (33–38 F) section of the meat display case for sale on that particular day This is an advantage to the consumer who wants to cook the poultry that night. However, this is a safe practice only if careful, constant control is maintained over the chilled inventory so that the product is not held beyond its overall shelf life in store and home. See Chapter 32 for a detailed discussion of shelf life of chilled poultry.

There has been some marketing of ready-to-cook turkeys in the form of a frozen, prestuffed, raw product. Extreme care should be exercised in the production and consumption of this type of product, in order to insure that the original bacterial count in the birds and stuffing is at a minimum, and that in roasting the internal temperature reaches a value sufficiently high to provide a safe product.

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