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Subject: frozen
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The frozen food studies are not straightforward: it depends on the type of food and the type of freezing including the problems that occur by temperature abuse (consistency).
The best method seems to be shock freezing.
Most studies seem to agree that nutrients are retained to some degree at least similar to fresh produce as sold in retail (meaning having gone through a distribution chain).
The vitamins are sealed by ice crystals that build a wall around the cell BUT while vitamins may be retained it is also clear that the texture of the item is affected by the ice crystals - therefore it does not FEEL the same as fresh (especially in the case of vegetables).

I am still waiting for concrete feedback from Max Planck and Robert Koch Institutes which i do not expect before week of Jan 4th.

All the best
David

Kinetic modelling of vitamin C loss in frozen green vegetables under variable storage conditions
- National Technical University of Athens, Department of Chemical Engineering, Laboratory of Food Chemistry and Technology, Greece

A systematic kinetic study of $_{L}$ -ascorbic acid loss of four green vegetables was conducted in the temperature range of freezing storage. The temperature-dependence of vitamin C loss in the −3 to −20 °C range was adequately modelled by the Arrhenius equation and activation energy ranged from 98 to 112 kJ/mol for the four frozen green vegetables. The developed models were validated in fluctuating time–temperature conditions, in order to establish their applicability in the real marketing path of the commercial products. Based on the models, the nutritional level can be estimated, at any point of the freezing chain, when the full time–temperature history is available. Comparison among different green vegetables showed that the type of plant tissue significantly affects the rate of vitamin C loss. Frozen spinach was found to be the most susceptible to vitamin C degradation, peas and green beans demonstrated a moderate retention, whereas okra exhibited a substantially lower loss rate.

Effect of frozen storage on the degree of vitamin B6 degradation in different foods
- Department of Food Chemistry, Faculty of Pharmacy and Biochemistry, University of Zagreb, Croatia

Investigation of the effect of freezing and storage at-18° C for 5 months on the stability of total vitamin B6 in foods of different origin leads to the conclusion that the decrease in vitamin B6 content ranged from 18.92% to 60.26% and that the loss is significantly greater in food of animal origin (an average of 55.0%). Obviously, biostructure, that is chemical composition, is one of the basic factors affecting the degradation degree of vitamin B6 in foods preserved by freezing. However, in relation of their biological value and with reference to the declaration allowing deep-frozen vegetables to be stored for 12–24 months, some foods of vegetable origin preserved by freezing exhibit a relatively high loss of biological value in terms of vitamin B6 as early as after 5 months of storage.

Mathematical models to evaluate temperature abuse effects during distribution of refrigerated solid foods
- Food Engineering Group, Department of Food Science and Technology, Oregon State University, USA

The increasing consumption of refrigerated foods in the USA opens new opportunities for food processors to satisfy consumer demands for minimally processed foods. Previous work has shown the need to reduce the frequency of temperature abuse. The development of a personal computer-based tool to evaluate the consequences of temperature abuse shows that, even when the fraction of the total storage time at an undesirable room temperature is rather small (2–3%), the reduction in shelf-life can be highly significant (20–30%). The effect of package size and heat transfer properties was also significant. These types of evaluations, needed to help reduce product losses, are expensive and time consuming without the help of the tool here presented.

The Effect of Fluctuating vs. Constant Frozen Storage Temperature Regimes on Some Quality Parameters of Selected Food Products
- Teagasc, The National Food Centre, Ireland
- University College Dublin, Department of Agricultural and Food Engineering, Ireland

Samples of frozen raw salmon, smoked mackerel, stewed pork pieces, ice cream, pizza (with a mozzarella cheese topping), hollandaise sauce, strawberries, and blanched broccoli were mildly temperature abused by subjecting them to temperature fluctuations below the freezing point. This involved three temperature fluctuation cycles of −30 °C to −10 °C to −30 °C on consecutive weeks followed by storage at a constant −30 °C for 8 mo. The samples were compared with duplicate sets held for 8 mo at a constant −60 °C (superfreezing) or −30 °C (control) and testing (objective and sensory) was conducted after 0, 1, 2, 4 and 8 mo. The temperature regimes had a larger effect on peroxide (PV) and free fatty acid (FFA) values than on any of the other parameters tested over the product range. The pattern in the data was the same for each fat-containing product in that superfreezing (−60 °C) gave the lowest PVs and FFAs, the control (−30 °C) was intermediate, while the fluctuating regime gave the highest values. PVs and FFAs also increased with length of time in frozen storage. While smoked mackerel had relatively high PVs and FFAs, rancidity was not a major problem in any of the fat-containing products as indicated by sensory tests. The temperature regimes had a minimal effect on texture, colour, water-holding capacity and drip loss on thawing for most of the products. However, superfreezing resulted in a better retention of vitamin C in strawberries.

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