The Effect of Stocking Procedure on Consumption of Shelf Life in Refrigerated Seafoods Displayed in Full Service Departments*

by

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Introduction

In a nationwide survey, the Food Marketing Institute (1987) reported that shrinkage in the refrigerated seafood line accounted for 10 to 15 percent of (departmental) sales. A direct cost, shrinkage proportionally reduces departmental contributions to store overhead. As well, the factors which manifest excessive shrinkage may raise customer concerns about the safety, freshness, and time available to use seafood purchases. These concerns could affect store loyalty, thereby eroding a source of competitive advantage to the firm.

There are two sources of shrinkage: a) paying for products not received (i.e. inconsistencies between invoices and deliveries) and b) spoilage. Insuring that orders match deliveries can eliminate the first source of shrinkage. This

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is best achieved by designing detailed, measurable product specifications, communicating them to vendors, and evaluating incoming deliveries against these criteria. Much has been written about proper receiving practices for food retailers (Gillespie, et al., 1977; Ward, et al. 1979; Coale, 1988; Hasselback, et al., 1984 and 1985).

With all perishable products, some spoilage is inevitable since the time required to sell them may exceed remaining shelf life. This situation is exacerbated with seafoods because, in many instances, a significant amount of shelf life has been consumed prior to retail receipt. In fact, retailers often exert management control over no more than the last 20 to 25 percent of remaining shelf life for many species (approximately 70 to 80 clock hours).

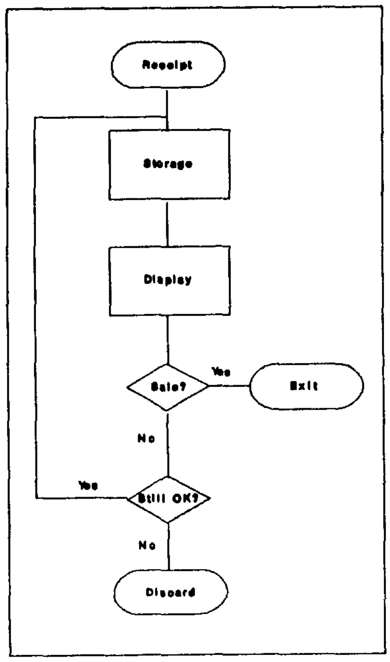
However, shrinkage due to rapid consumption of remaining shelf life occurs because of high product temperatures which speed microbial action, inadvertent contamination/cross contamination which increases the abundance of spoilage organisms (also reducing the time required to putrefy the product), or interaction between these conditions. And given the limited amount of shelf life remaining upon receipt, methods which do not insure that products with the least amount of shelf life are sold first may also account for a significant proportion of avoidable shrinkage.

Shrinkage resulting from spoilage and improper rotational sequences can be sharply reduced by correcting deficiencies in the retail quality management process. This process includes in-store protocols used at each step in the retail inventory cycle (Figure 1), as well as the employee handling required to move products from one step in the cycle to another. Improving the quality process is particularly important within food retailing since providing consumers with safe, fresh, long lasting products is linked to management programs; not technologies.

Diminution in quality cannot be recaptured. Therefore to reduce shrinkage and pass along fresh, long lasting seafoods to consumers, work plans, methods, protocols, etc. must *simultaneously* maintain low product temperatures, employ good sanitation practices, and respect stock rotation sequences *throughout* the inventory cycle. If all of these criteria are not satisfied at each step within the cycle, remaining shelf life can be rapidly consumed.

Figure 1

The Retail Inventory Cycle
For Refrigerated Seafoods



Product display is often overlooked for its effect on spoilage. This step can significantly contribute to rapid spoilage if products remain on display for long periods prior to sale (e.g. 10 to 14 hours between initial stocking and sale) *and* the stocking procedure employed cannot maintain optimally low product temperatures. With many products having minimal shelf life upon receipt, maintenance of low product temperature in the display step can mean the difference between a sale or a discard.

Since stocking procedures are the means of achieving display management objectives, they should be consistent with the amount of time products remain on display prior to sale. Thus, if displayed product turns over every 4 or 5 hours, stocking procedures should focus on maximizing eye appeal at the expense of shelf life since the practical effect of higher product temperatures is offset by rapid inventory turnover. Conversely, longer case residence times suggest using stocking procedures which also maintain low product temperatures.

While retail management intuitively recognizes the need to maintain cold product temperatures in all but the fastest turning situations, two factors complicate effective management of the display step. First is the mistaken assumption that display equipment per se is capable of maintaining low product temperatures, regardless of procedures used to stock the case. But, maintaining low product temperatures is determined by stocking procedure (i.e. the manner that product and ice are combined).[1] The second impediment to effective display management is the lack of performance data which measures the amount of shelf life consumed when different stocking procedures are used.

To this end, the paper a) outlines the quantitative impacts that different product temperatures have on shelf life and b) measures how various stocking procedures commonly used by the food retailing sector affect product temperature and thus the rate of decomposition. By comparing the shelf life consumed under a variety of stocking procedures with expected case residence time, retail management can select those stocking procedures which best balance the objectives of eye appeal and maintenance of shelf life.

The Influence of Product Temperature On Shelf Life

Holding product temperature constant, the progression high protein foods make from fastidiously fresh to completely putrid is inevitable and predictable (Bramsnaes, 1965). However, when product temperature is increased, the rate of spoilage accelerates (Gorga and Ronsivalli, 1988). Specifically, cod (*Gadus mohura*) held at 32° F since death is of acceptable quality for about 336 hours (14 days) (Figure 2). At a holding temperature of 40° F, the same product is acceptable for only 168 hours (7 days). The difference is not the amount of shelf life available, but the rate at which it is consumed.

Peters (1986) used this relationship to compute the amount of shelf life lost per elapsed hour (i.e. the rate of spoilage) (Figure 3). Therefore, by knowing product temperature and length of holding period, the amount of shelf life consumed throughout any step in the retail inventory cycle can be estimated.

Evaluating the Influence of Stocking Procedure Upon Product Temperature

Food retailers may use a number of different stocking procedures. Additionally, these different stocking procedures may be combined with various case door opening regimens, different ambient case airspace temperatures and numerous models of equipment thereby creating hundreds of unique combinations; all of which impact product temperature. Evaluating, let alone enumerating, each of these unique combinations is not practical. Instead, the approach taken here is to focus on those elements which are considered critical in determining product temperature. Those elements are different ambient case temperatures and specific stocking procedures. By evaluating combinations of these two considerations, most of the differences in product temperature can be addressed.

All stocking procedures were conducted under ambient case airspace temperatures of 40° F, 50° F, and 60° F. Evaluating stocking procedure performance at different temperature settings is important for several reasons. First, the physical placement of the thermistor within the case may vary by model as well as from store to store; thereby leading to inaccurate assessments of air space temperature above the product. Second, periodic opening and closing of case doors also affects air temperature above the product. Third, operating characteristics of refrigeration systems suggest that variability in case air temperatures over time are a normal occurrence. For example, the preselected case temperatures were achieved based on an average computed over each ten hour trial. However, mechanical refrigeration equipment can create dramatic variations in case air-

Figure 2

Hours The Product is Acceptable
As Determined by Product Temperature

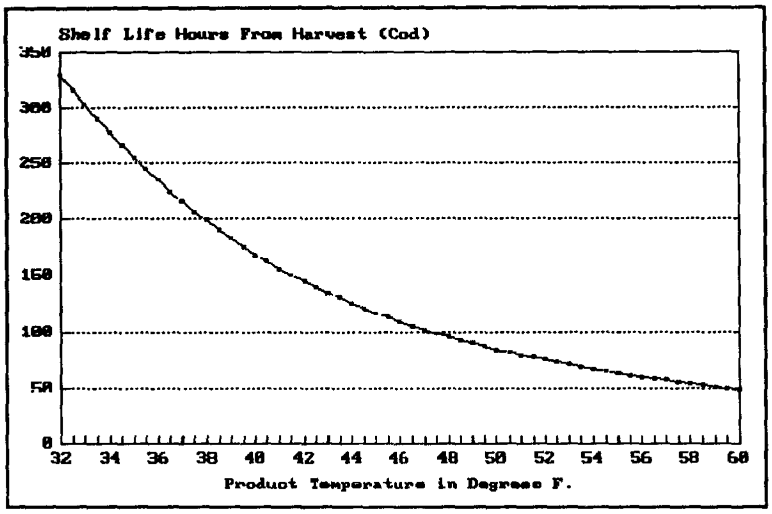
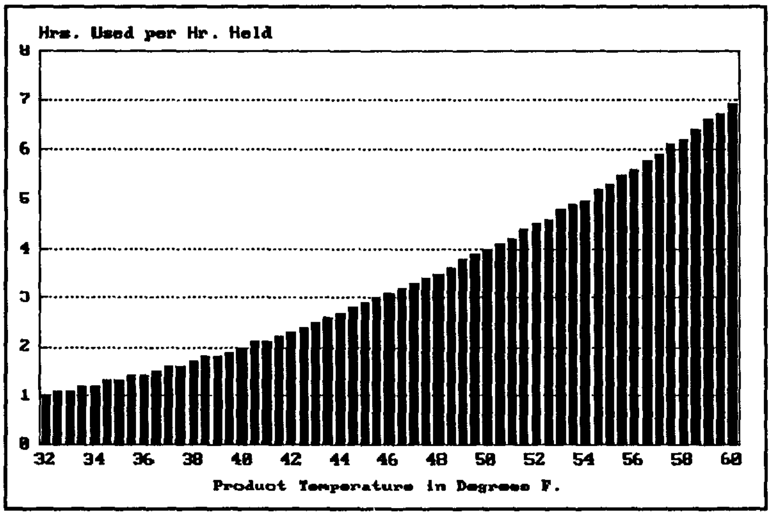


Figure 3

Hourly Shelf Life Consumption Rates
Determined by Product Temperature



space temperature as the compressor cycles; particularly at lower settings (Figure 4).

All trials were carried out using a full service display case which relied on ice and supplemental refrigeration for chilling. Prior to stocking product in the case, a four inch layer of flaked ice was added. Perforated, half size stainless steel steam table pans were used in all stocking procedures with fillets.

Four stocking procedures were evaluated using fillets. These included: a) pans of fillets placed on bed ice, b) pans of fillets embedded in ice, c) pans of fillets embedded in ice with light top icing, and d) pans embedded in ice with fillets separated from the pan bottom by a 1 inch airspace created with 2 inverted 2S foam meat trays. A stack of three fillets were used in the first three treatments while two fillets were used in the false bottom stocking procedure.

Thermocouples were attached in the approximate geometric center of each fillet (the warmest location). Fillet temperatures were recorded every 30 seconds, and averaged into container values over the hypothetical 9.5 hour sales day. Using spoilage rates which correspond to average container temperatures (Figure 3), the total amount of shelf life consumed under each stocking procedure was computed.

Findings

On ice stocking procedure. This stocking procedure uses the ice bed as a platform on which to display inventory. Due to pan placement, 44 percent of the container surface is ineffective as a heat exchanger. And because pans are placed on the bed of ice rather than being embedded in it, there is no way that the cold air generated at the air/ice interface can insulate product from higher ambient temperatures.

Products placed on ice were quite sensitive to ambient case temperature settings between 40° F and 50° F, but exhibited similar changes in average container temperature over time between 50° F and 60° F (Figure 5). Computed average container temperatures were 36.2° F at the 40° F ambient case setting and 40.2° F at both 50° F and 60° F settings. Over a 9.5 hour hypothetical sales day, the estimated consumption of shelf life ranged from 13.3 hours (40° F setting) to 19 hours (both 50° F and 60° F settings).

In ice stocking procedure. Pans were placed in carved depressions in the bed of ice such that a) all five container surfaces were completely contacted by ice and b) the lip of the pan was even with the top of the ice bed. By embedding pans in ice, this stocking procedure maximizes the opportunity for ice to conduct heat away from the product through all container surfaces. Also, physical placement of pans in the ice bed allows cold, dense air to settle into pans which, in part, insulates fillets from higher ambient temperatures.

Products gained heat within the first 90 minutes on display at all case settings but stabilized at 35° F, 38° F and 39° F depending upon case airspace temperature (Figure 6). Average container temperatures at the three ambient case airspace settings were 34.3° F, 37.7° F and 38° F respectively. Based on these average container temperatures, estimated shelf life consumption was 12.4 hours (40° F setting), 15.2 hours (50° F setting) and 16.2 hours (60° F setting).

Pans placed in ice with periodic top icing. Once the pan was embedded in ice and fillets were introduced, a light periodic top icing regimen was maintained over the 9.5 hour trial. Cube ice was used as a top dressing such that the product was visible (not buried), and melting ice was allowed to flow over fillet surfaces.

Despite a 20° F (50%) difference in case temperature, average product temperatures in this stocking procedure exhibited minimal variation (Figure 7). However, a warmer airspace did require adjustment in the time interval between periodic replenishment of top ice; being more frequent at the higher temperature.

False bottoms added to pans embedded in ice. This approach focused on making half size stainless steel steam table pans more shallow thereby allowing retailers to cover the interior of the case with less product. It is sometimes used when management expects the interval between initial stocking and sale to be long. The rationale sug-

Figure 4

Ambient Case Airspace Temperature
Histories When Set at 40° F,
50° F, and 60° F

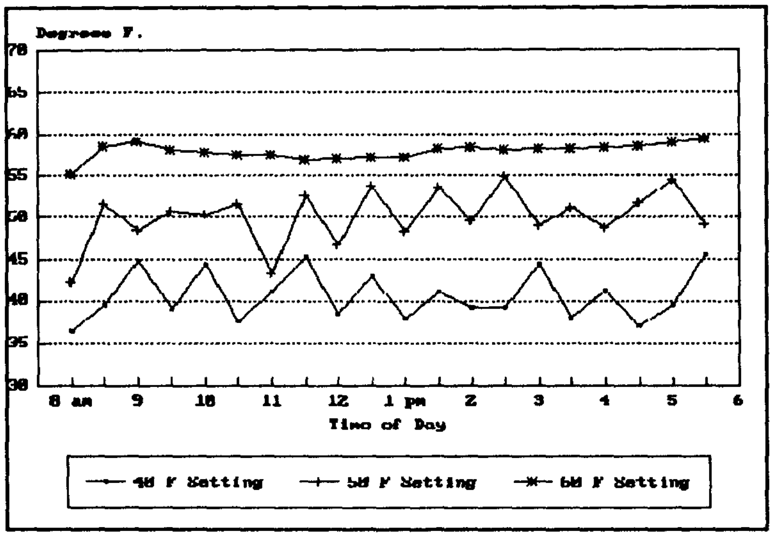


Figure 5

Pans of Fillets Placed On Ice
Using a Refrigerated Case
Set at 40° F, 50° F, and 60° F

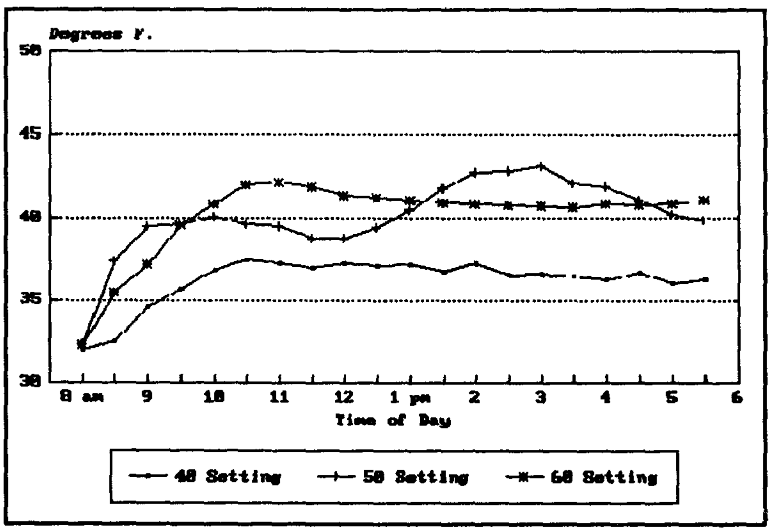


Figure 6

**Pans of Fillets Placed In Ice
Using a Refrigerated Case
Set at 40° F, 50° F, and 60° F**

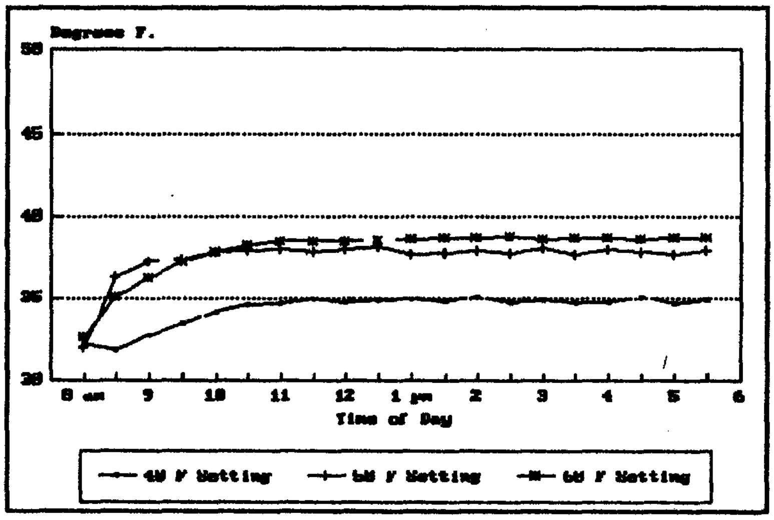
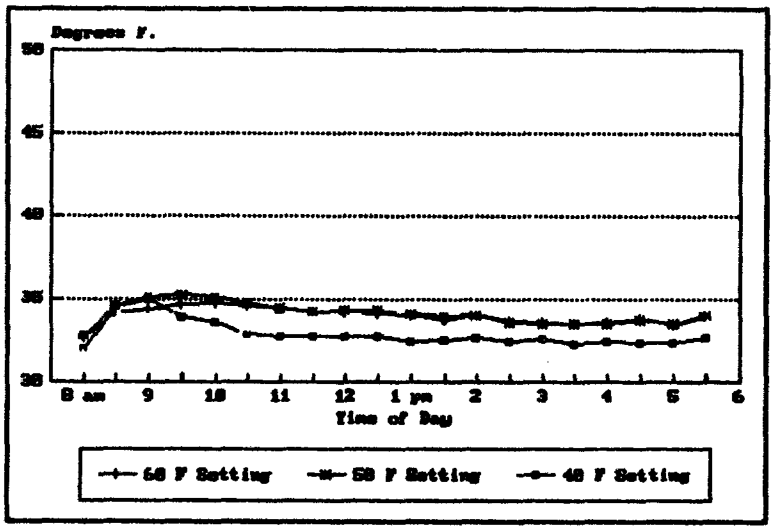


Figure 7

**Pans of Fillets Placed In Ice,
Periodically Top Iced In a Refrigerated Case
Set at 40° F, 50° F, and 60° F**



gests that since the surface area of the case is effectively covered, the use of false bottoms provides shoppers with images of abundance, but allows the firm to display less product within a given sales day.

Unfortunately, false bottom use achieves the objective of displaying less product per sales day, but with a high cost in terms of lost shelf life. At temperatures above 40° F, products rapidly gain heat from the ambient case airspace (Figure 8). The effect on shelf life consumption was dramatic, ranging from 16 hours being lost (40° F setting) to 28.5 and 29.5 hours respectively at the 50° F and 60° F settings.

Discussion

It is hardly surprising that products placed in cold environments and stocked such that the direct and indirect effects of ice are maximized return cold average temperatures. Thus, when stocking procedures were evaluated at the same ambient case setting, all were significantly different at the 95 percent level as computed using least significant difference.

When similar stocking procedures were evaluated over the range of case temperature settings, all stocking procedures which relied on indirect uses of ice were impacted by airspace temperatures. Interestingly, significant differences only exist between ambient settings of 40° F and 50° F, but not between the 50° F and 60°F settings.

What is surprising is the impact that seemingly small differences in stocking procedure have on product temperature and therefore the amount of shelf life consumed (Table 1).

So long as ice chills indirectly, product temperature will, in part, be determined by case airspace temperature. The extent to which case setting affects product temperature depends upon the particular stocking procedure. Those procedures which compromise the effectiveness of indirect chilling (e.g. on ice method or false bottom method) account for significantly warmer average temperatures and additional reductions in shelf life when compared to more effective stocking procedures.

The top icing method utilized both the direct and indirect effects of ice as a chilling mechanism. When both effects are combined in one stocking procedure, product temperature is minimized, chilling is rapid, there is almost no variation in product temperature, and products remain cold regardless of different ambient case (or room) temperatures. As well, shelf life consumed per clock hour on display is minimized thus affording food retailers the maximum amount of time to sell the product. Whereas the results of indirect uses of ice are partially dependent upon ambient temperature, the judicious, direct use of ice provides identical results regardless of ambient settings. From the standpoint of design and implementation of stocking procedures firm-wide, this is the most significant managerial benefit of direct use of ice.[2]

When compared to other stocking procedures, the false bottom method exhibits the greatest increase in shelf life consumption between 40° F and 60°F; practically doubling the number of shelf life hours lost per actual display hour. With a slow turning inventory situation, stocking procedures are required which maximize the amount of product sales time. Ironically, the use of a false bottom rapidly reduces shelf life for those food retailers who most need to conserve it.

Conclusions

Shelf life of seafood is continuously consumed at refrigerated temperatures, with the amount lost each hour proportional to increases in product temperature. Maximizing remaining shelf life and insuring product safety are best achieved by maintaining product temperatures near 32° F.

Product temperature is ultimately influenced by the amount of heat gained from ambient conditions and the length of holding period. When the time interval between initial stocking and sale is more than 5 hours, seafoods must be insulated from warmer temperatures to control heat gain.

Depending upon case residence times, the amount of shelf life lost can be significant since

Figure 8

Pans of Fillets Placed In Ice With False Bottoms In a Refrigerated Case
Set at 40° F, 50° F, and 60° F

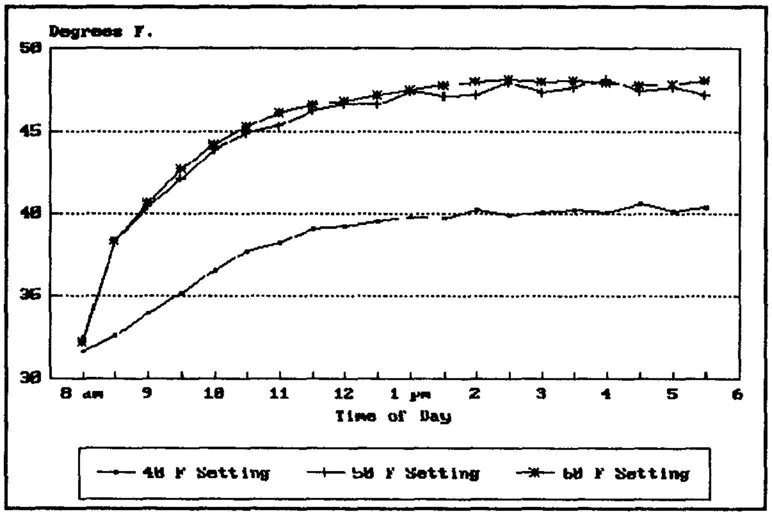


Table 1

Average Container Temperature and Shelf Life Consumed over a 9.5 Hour Hypothetical Sales Day

	Average Ambient Case Airspace Temperature					
	40° F		50° F		60° F	
Stocking Method	Avg. Temp.	Hrs. Lost	Avg. Temp.	Hrs. Lost	Avg. Temp.	Hrs. Lost
Indirect use of ice						
on ice	36.2	14.3	40.2	19.0	40.2	190
in ice	34.3	12.4	37.7	15.2	38.0	162
in ice, f.bottom	38.2	16.2	45.3	27.6	45.7	285
Direct & indirect use of ice						
in ice, top icing	33.0	10.5	33.3	10.5	33.3	105

displayed products typically warm up during the sales day. However, stocking procedures can insulate product from higher ambient temperatures. The four stocking procedures evaluated here fell into three categories: those that work regardless of ambient case settings, those which work under some, but not all ambient settings, and those which do not work under any ambient case settings.

Embedding pans of fillets in bed ice and periodically top icing them quickly stabilizes fillet temperature at 32° F - 33° F, regardless of ambient conditions. Of course, higher ambient temperatures require more frequent applications of ice to maintain optimal product temperatures. Sales flexibility (shelf life) is maximized with this stocking method.

At case settings of 40° F, embedding pans of fillets in ice returns average container temperatures close to products which are top iced. However the beneficial effects of indirect chilling are compromised at higher case temperatures.

The false bottom procedure is often employed by food retailers who need additional time to sell the product. While this approach provides images of abundance, it minimizes the indirect chilling effects of ice, while simultaneously maximizing product surface area exposed to warmer, ambient temperatures. The result is a rapid reduction in shelf life at all ambient settings.

Endnotes

[1]The effectiveness of ice is strictly determined by the manner in which it is used. Ice is most effective at removing heat when it melts over the product. Direct contact with melting ice chills products about 5 times quicker than cold air (Bramsnaes, 1965). Melting ice, being such an efficient heat removal mechanism, maintains constant, low product temperatures regardless of ambient air temperature.

When product and ice are separated (i.e. products are placed in pans and then embedded in bed ice) chilling from ice occurs through conduction, and depending on stocking procedure, creation of a cold air barrier which acts to insulate products from a warmer ambient environment. There are two important considerations in the indirect use of ice. First, stocking procedure (i.e. depth of the pan in ice) determines the extent of indirect benefits. Second, ambient case airspace temperature influences the effectiveness of these indirect means since at higher ambient temperatures the beneficial effects of conduction and insulation may be substantially reduced.

[2]Some workers have suggested that placing ice directly on some species of extremely fresh skinless flounder fillets may slightly alter muscle coloration.

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