The Impacts of Scheduling price Discounts for Perishable Foods on Retailer Performance

Chung, Jaekwon*, Choi, Daeheon**, Park, Iljin***

Perishable foods, which spoil within a short time, and therefore experience significant value deterioration, represent a product category that is important to success in the food retail industry. This is because perishable foods can significantly influence sales in food retail stores, and are considered by consumers as an important indicator of a store's quality. Despite the importance of perishable foods, food retailers face challenges in pricing perishables, because they require a more complex pricing procedure than non-perishable products. Unlike non-perishable products, perishable foods experience a significant loss of value as they approach their expiration dates. Also, it is true that consumers' willingness to pay for perishable foods generally decreases as the expiration dates approach. Consumer confidence in perishable foods decreases as expiration dates come closer, since fewer days remaining can mean deterioration of freshness, and foods that have remained in inventory for a long time are thought to be inferior. Therefore, it is important to dynamically manage the price of perishable foods to compensate for the value deterioration associated with the approaching end of the selling period.

Many previous studies have investigated the pricing of perishable products, and most of these studies focused on the optimal price structure to maximize profit. A recent study has investigated the effects of discount frequency on retailer performance, using a simulation model. However, these prior studies have failed to show the effects of the price discount starting time on retailer performance. Therefore, this study aims to demonstrate how the price discount starting time for perishable foods could affect retailer performance in terms of inventory aging, waste due to unsold products, and sales volume. A simulation model, which represents the general business process in the food retail stores, and conducted in the C programming language, was built. The general business process at food retail stores and consumer demand assumptions in Chung and Li(2013ab) was used to build the simulation model in this study.

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* First Author, Assistant Professor of Marketing, Kookmin University, College of Business Administration (jchung@kookmin.ac.kr)

** Corresponding Author, Assistant Professor of Operations Management, Kookmin University, College of Business Administration (dhchoi@kookmin.ac.kr)

*** Computer Programmer, JoyCity Corporation (iljin7432@hotmail.com)

The results of this study present the value of an earlier price discount and its ability to increase retailer sales, reduce wastage due to unsold products, and mitigate the inventory aging of perishables. Specifically, this study found that for a specific perishable food, for which the average demand exceeds supply, an earlier price discount does not assist retailers in improving performance. When the average demand is equal to supply, an earlier price discount slightly increases sales volume. As for wastage due to unsold products and inventory aging, retailers can expect positive impacts from an earlier price discount. For a specific perishable food, for which the average supply exceeds demand, significant positive impacts can be expected from an earlier price discount. An earlier price discount can enhance sales volume, reduce waste due to unsold items, and mitigate inventory aging. These positive impacts are expected to be more significant for perishable foods that have relatively longer shelf lives. With the results of this study, we propose that retailers should discount the price of perishable foods earlier, but at a smaller rate, by considering the value lost as the remainder of shelf life decreases.

This study presents valuable practical implications and academic contributions, which provide a better understanding of the value of earlier price discounts for perishable foods. This study has several limitations. This study has investigated the general impacts of an earlier price discount for perishable foods on retailer performance; on the other hand, it does not show the optimal time and rate of price discounting. Furthermore, this study assumed that every consumer behaves rationally, and considers their consumption needs when making a purchase. However, some consumers may not behave rationally when purchasing perishable food. Further studies considering these issues may provide a better understanding of the positive impacts of an earlier price discount for perishable foods.

Keywords : Perishable foods, Inventory aging, Food pricing, Food retailing

Ⅰ. Introduction

Among the various types of foods that food retailers sell, perishable foods have a significant influence on business performance. Therefore, these produces represent a core product category for success in the market(Chung and Li 2013a). Perishable foods are defined as having a shelf life of 30 days or less and high value deterioration rate due to storage conditions(Donselaar, Woensel, Broekmeulen and Fransoo 2006). For the retail grocery industry in the United States of America, perishable foods such as dairy, baked goods, fresh meat, and seafood account for a little over 50% of overall sales(Heller 2002). Consumers often use perishable foods as an indicator of a store's value(Kerin, Jain and Howard 1992). However, retailers frequently face challenges in the pricing of perishable foods. Because of their short lifespan and high tem perature-sensitive characteristics, perishable foods require a more complex pricing procedure than non-perishable products.

Pricing is an important tool in marketing strategies, and therefore has a significant effect on consumer purchasing behaviors and business performance(Hinterhuber 2004). Managers typically make pricing decisions based on three key factors: cost of pro duction, competitor prices, and customer value(Hinterhuber 2008; Shapiro and Jack son 1977). Perishable foods, however, experience significant value deterioration as they reach their expiration dates(Chung and Li 2013a). Consumers consider the perceived value, benefits, and sacrifices of the pro ducts when purchasing(Shapiro and Jackson 1977). Consumer confidence in perishable foods decreases with inventory aging for three reasons: (1) less remaining shelf-life, (2) freshness(quality) deterioration, and (3) a general perception of inferior quality attached to foods that have remained in inventory for a long time(Sarker, Mukherkee and Balan 1997). Consequently, consumer willingness to pay for perishable foods typically decreases with the increasing perception that perishables will lose their freshness as the expiration(or sell by) dates approaches(Eom 1994; Tsiros and Heilman 2005). Therefore, it is important to dyna mically adjust the price of perishable products by balancing the decrease in the product's value associated with the approa ching end of the selling period to improve profitability(Elmaghraby and Keskinocak 2003; Chung and Li 2013ab).

Many studies have presented pricing models that are applicable to general peris hable products, such as perishable foods, seasonal fashion goods, weekly magazines, theatre seats, and airline tickets, to maximize profit(Aviv and Pazgal 2008; Bitran and Mondschein 1997; Dasu and Tong 2010; Federgruen and Heching 1999; Gallego and Ryzin 1994; Kincaid and Darling 1963; Li 2001; Rajan, Steinberg and Steinberg 1992; Su 2007). Researchers have developed dynamic pricing models for general peris hable products based on various demand assumptions, including myopic demand, strategic consumer demand, and price-dependent demand. Conversely, the pricing of perishable foods has received relatively little attention in the literature. Previous studies were developed based on enhanced traceability systems that can provide precise information regarding food shelf-life(Li, Tang, O'Brien and Wang 2006; Liu, Tang and Huang 2008; Wang and Li 2012). Prior studies on the pricing of either general perishable products or perishable foods have focused on optimal dynamic pricing to achieve higher profitability using various numerical mathematical assumptions. A recent study on perishable food pricing investigated the effects of frequency of discount over a food's shelf-life on retailer performance using a simulation model (Chung and Li 2013b). However, these studies have not focused on the effects of price discount starting time on retailer performance. Therefore, this study investi gates how the price discount starting time of perishable foods can influence retailer performance in terms of inventory aging, wastage because of unsold products, and sales volume. The results of this study provide practical insights into the benefits of early price discounting.

Ⅱ. Literature Review

Kincaid and Darling(1963) presented one of the earliest studies investigating a pricing model to maximize the sales of products to be disposed of within a specific time period. Since then, many studies have explored pricing models to improve the profitability of perishable products. Earlier studies on pricing models for general perishable products, such as Bitran and Mondschein(1997), Federgruen and Heching(1999), Gallego and Ryzin(1994), Li(2001), and Rajan, Steinberg and Steinberg(1992), were developed based on the assumption that consumers do not consider the possibility of a future price reduction. These studies considered myopic consumers who purchase immediately if the price of the product is equal to, or lower than, their valuation.

Conversely, recent studies on pricing, including those by Aviv and Pazgal(2008), Dasu and Tong(2010), Elmaghraby, Gulcu and Keskinocak(2008), Levin, McGill and Nediak(2009), and Su(2007), have paid attention to forward-looking or strategic consumer purchasing behavior. These studies used strategic consumer demand when developing pricing models for perishable foods. Levin, McGill and Nediak(2009, p.32) noted that "experienced consumers may now behave strategically by timing their purchases to anticipated periods of lower price." Strategic consumers are aware of future price adjustments, and decide whether to purchase now at a high price or wait until the price decreases.

Li, Tang, O'Brien and Wang(2006), Liu, Tang and Huang(2008), and Wang and Li(2012) studied the dynamic pricing of perishable food products. They investigated dynamic pricing models with enhanced food traceability systems that enable the detection of precise information about food value. These studies highlight the benefits of the dynamic pricing of perishable foods based on price and perceived value-dependent demand. In these studies, a more precise food value(i.e., days left until expiration date) is identified through enhanced food traceability systems(e.g., RFID).

Previous studies on the pricing of perishable products presented optimal or dynamic pricing models based on various demand assumptions. Conversely, the demand assumptions considered in prior studies have not sufficiently considered the specific situation that food consumers frequently face when purchasing perishable foods. Chung and Li(2013a) showed that unlike other perishable products, the objective value of identical perishable food products may vary depending on the time they go on display for sale. Assume that food retailers normally reduce the prices of perishable foods when the expiration date is near(e.g., one day prior), and they replenish foods on a daily basis. A specific food item not sold on one day will be displayed with identical foods replenished the next day. These produces may have different shelf lives remaining, but their prices will be the same if they have more than one day of shelf-life remaining.

Chung and Li(2013b) studied the effects of discount frequency on retailer performance for perishable foods. They used a need-driven consumer demand scenario to simulate the situations that consumers frequently face. Their study shows that retailers can improve sales volume and profitability, and reduce wastage because of unsold products, by more dynamically managing the price of perishable foods. However, different pricing strategies and discount starting times have different effects on inventory aging and retailer performance. As indicated in the Introduction, consumer confidence decreases for foods that have been on display for a long time because of freshness deterioration and a shorter remaining shelf-life(Sarker, Mukherkee and Balan 1997). Consumers often use perisha ble foods as an indicator of a store's quality(Kerin, Jain and Howard 1992). Retailers need to prevent the aging of perishable foods to provide fresher foods. Feng and Gallego(1995) studied optimal starting and stopping times for end-of-season sales. However, their study focused on products such as airline seats, hotel rooms, and theater seats, whose prices should increase or decrease as the end of selling period approaches, and failed to consider inventory aging. Conversely, this study focuses on how the discount starting time for perishable foods affects inventory aging, sales volume, and wastage. This approach can provide a better understanding of the effectiveness of an earlier discount on performance. A simulation model was deve loped using the C programming language to generate the results of this study.

Ⅲ. Model Assumptions

The simulation model, which was devel oped using the C programming language, was used to evaluate the effects of discount starting time for perishable foods on retailer performance in terms of inventory aging, sales, and wastage. The general business process, including inventory management and consumer purchasing decisions at food retail stores, described in Chung and Li(2013ab), was used to build a simulation model that represents the ordering and selling process in retail stores. In this simulation, a 90-day(one quarter) period was chosen as the sales time for a specific perishable food product. The average output values from 100 runs of simulation were provided as results.

3.1 Inventory

Retailers typically replenish perishable foods from their suppliers on a daily basis to maintain target inventory levels(Chung and Li 2013a). Therefore, we set i as the target inventory level, and the inventory of a specific perishable food is replenished up to i on a daily basis in this simulation. In other words, the amount of inventory for a specific perishable food is i on the first day, and the number of the specific perishable product sold on the first day will be replenished on the morning of the second day in the simulation. This procedure was adopted to fill the inventory for a specific perishable food product up to the target inventory level. To evaluate how the effects of the price discount starting time for perishables on retailer performance varies in cases where demand normally exceeds supply, supply normally exceed demand, and demand normally equals supply for a specific perishable food, we test for various possibilities of i spanned by i $\in$ {40, 60, 80}.

3.2 Price

To evaluate the effects of starting time of discounting perishable foods on retailer performance, we test various price discou nting time(Table 1). In this Table, s represents the length of shelf-life, and t represents day(day 1 = t 1). We test two different possibilities of s because the effects may vary depending on the length of the product's shelf-life.

We aim to evaluate the effects of the price discount starting time for perishable foods on inventory aging, sales, and wastage for a specific perishable food. The effects of discount frequency are not our focus. Therefore, without loss of generality, we assume that the retailer discounts a specific perishable food once during its shelf-life. Therefore, only two price possibilities are considered; P0 represents the initial price, and P1 represents the discounted price; thus P0 〉 P1. To represent the various possibilities of the price discount starting time, we consider situations that a retailer does not discount the price at all, and makes a discount once from the second day of shelf-life, ⋯, to discount the price on the last day as shown in Table 1.

3.3 Consumer Purchasing Behavior (Demand)

Prior studies on pricing used a Poisson distribution for consumer demand, for example, in Aviv and Pazgal(2008) and Chung and Li(2013b). In this study, the consumers' arrival rate to purchase a specific perishable food at a retail store also follows a Poisson process in the simulation with the average arrival of λ consumers per day. Considering the various possibilities of i, we set λ = 60 for all simulation tests to test how the effect vary depending on the level of demand and supply.

Further, each consumer's purchasing decision for a specific perishable food follows the need-driven demand scenario used in Chung and Li(2013b). Following the need-driven demand scenario(Chung and Li 2013b), in this simulation, consumers have their own requirements regarding the number of days left to expiration date(r remaining shelf-life, $r \in \{1, 2, \cdots, s\}$) to purchase a specific perishable food. Each consumer's r follows a normal distribution; r

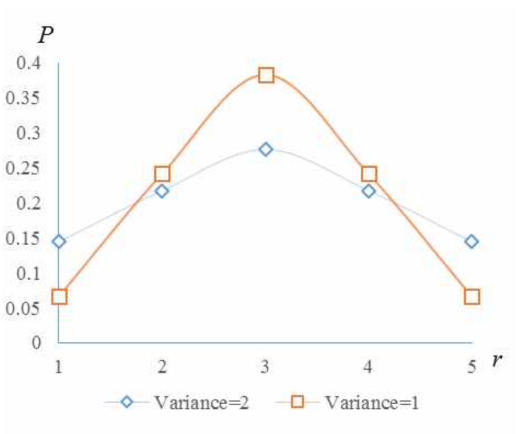
〈Table 1〉 Pricing in the simulation

t	Price on day t													
	s = 5					s = 9								
	Cases					Cases								
	1	2	3	4	5	1	2	3	4	5	6	7	8	9
1	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*
2	*P0*	*P0*	*P0*	*P0*	*P1*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P1*
3	*P0*	*P0*	*P0*	*P1*	*P1*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P1*	*P1*
4	*P0*	*P0*	*P1*	*P1*	*P1*	*P0*	*P0*	*P0*	*P0*	*P0*	*P0*	*P1*	*P1*	*P1*
5	*P0*	*P1*	*P1*	*P1*	*P1*	*P0*	*P0*	*P0*	*P0*	*P0*	*P1*	*P1*	*P1*	*P1*
6	*	*	*	*	*	*P0*	*P0*	*P0*	*P0*	*P1*	*P1*	*P1*	*P1*	*P1*
7	*	*	*	*	*	*P0*	*P0*	*P0*	*P1*	*P1*	*P1*	*P1*	*P1*	*P1*
8	*	*	*	*	*	*P0*	*P0*	*P1*	*P1*	*P1*	*P1*	*P1*	*P1*	*P1*
9	*	*	*	*	*	*P0*	*P1*	*P1*	*P1*	*P1*	*P1*	*P1*	*P1*	*P1*

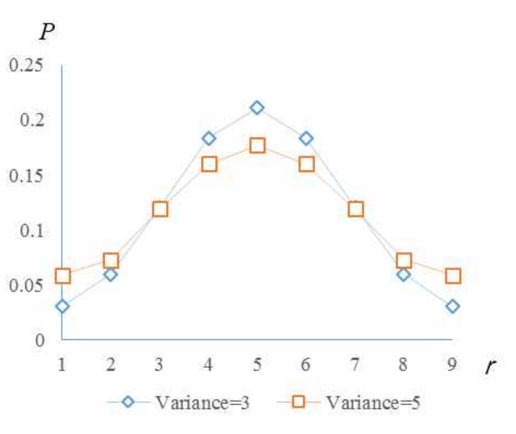
Note: P0 〉 P1

~ N(μ, σ 2). In this study, μ = s/2 was selected with two possibilities of σ 2 based on the assumption that the possibilities of consumers requiring one day or full days of shelf-life is lower than that with the median shelf-life for purchase(Chung and Li 2013b). Figures 1 and 2 show the r distributions of s possibilities. In this simulation, a consumer will not purchase a specific perishable food if all the displayed stock of the food has less than his or her required days left, or if the specific perishable food is sold out. If there are the foods having equal to or greater than his or her required remaining days left, then he or she purchases the product with (1) the cheapest price and (2) the longest remaining days left from among the products that have equal to or greater than his or her required remaining days left(Chung and Li 2013b)

For example, suppose a consumer needs a specific perishable food with three days of remaining shelf-life for purchase, and the displayed stock of that specific perishable food has 2, 3, 4 and 5 days of remaining shelf-life. The full shelf-life of the specific perishable food is 5 days. If the retailer discounts that perishable food from 4 days onwards(case 5 in Table 1, s = 5), then he or she purchases the food with 4 days remaining in the simulation based on the following need-driven scenario. Among the displayed stock of that food, the items that meet his or her shelf-life requirements are the foods with equal to or greater than 3 days remaining. Among the foods that fulfill his or her required remaining shelf-life for purchase, the foods with 3 and 4 days remaining have the cheapest price because the retailer discounts the price of that food from 4 remaining days left. Among these items, the foods with 4 days of shelf-life remaining have the longest shelf-life. When



〈Figure 1〉 Consumers' r distribution, s = 5



〈Figure 2〉 Consumers' r distribution, s = 9 the retailer does not discount the price(as in Case 1 in Table 1), only the latter condition applies. The need-driven demand scenario considers the possibilities of specific purchasing situations in which the displayed stock of a specific perishable food has different days of shelf-life remaining, but has the same price because of various pricing scenarios and the daily replenishment policy.

Ⅳ. The Results

As indicated in Section III, we test two different possibilities of $\sigma 2$ for the distribution of r. To simplify the results, we consider the average results of the simulation under the same level of i with two possibilities $\sigma 2$. For s = 5, the results show 15 combinations spanned by i ∈ {40, 60, 80} and five settings for the discount starting time(Table 1). For s = 9, the results show 27 combinations spanned by i ∈ {40, 60, 80} and nine cases for pricing(Table 1). For s = 5, we refer Instance 1-1 for the result spanned by i = 40 and Case 1 in Table 1, ⋯, Instance 1-5 for the result spanned by i = 40 and Case 5 in Table 1, ⋯, Instance 3-5 for the result spanned by i = 80 and Case 5 in Table 1. The same method was used to refer instances for s = 9.

4.1 The Effect of Discount Starting Time on Sales Volume and Wastage

Table 2 provides the simulation results for the effects of discount starting time on sales volume and wastage because of unsold products.

First, the results presented in Table 2 show that when i = 40, which means that the inventory level is significantly less than the number of consumers demanding a specific perishable food, the price discount starting time does not affect the number of products sold, wastage because of unsold products, or the number of consumers leaving for both s = 5(Instances 1-1 to 1-5) and 9(Instances 1-1 to 1-9). These results indicate that when demand normally exceeds supply, retailers do not need to discount the prices of perishable foods because a price discount does not affect retailer performance. It is noted that in general, when i = 40, the number of consumers leaving is significantly higher than that at i = 60 or 80, leading to fewer products sold. This is because of the need-driven scenario, in which consumers do not purchase when the product is out of stock.

Second, when i = 60, representing the retailer has accurately predicted the demand and stocked the optimal level of inventory, as the retailer discount the price earlier, the

〈Table 2〉 The summarized results of simulation tests

Instance	s = 5			Instance	s = 9		
	NS	NW	NL		NS	NW	NL
1–1	3599	0	1803	1–1	3599	0	1801
1–2	3599	0	1803	1–2	3599	0	1801
1–3	3599	0	1803	1–3	3599	0	1801
1–4	3599	0	1803	1–4	3599	0	1801
1–5	3599	0	1803	1–5	3599	0	1801
2–1	5095	14	302	1–6	3599	0	1801
2–2	5103	2	296	1–7	3599	0	1801
2–3	5109	0	290	1–8	3599	0	1801
2–4	5115	0	285	1–9	3599	0	1801
2–5	5121	0	279	2–1	5115	1	284
3–1	5321	306	77	2–2	5116	0	284
3–2	5339	146	58	2–3	5117	0	283
3–3	5361	5	37	2–4	5117	0	282
3–4	5379	0	18	2–5	5118	0	282
3–5	5396	0	1	2–6	5119	0	281
				2–7	5120	0	280
				2–8	5121	0	279
				2–9	5123	0	277
				3–1	5345	143	53
				3–2	5348	100	50
				3–3	5357	40	41
				3–4	5364	3	35
				3–5	5370	0	28
				3–6	5379	0	20
				3–7	5384	0	14
				3–8	5391	0	8
				3–9	5397	0	1

Note: NS–Number of product sold, NW–Number of disposed products because of unsold, NL–Number of consumer leaving

number of products sold increases slightly because the number of consumers leaving decreases slightly for both s = 5 and 9. When s = 5, the number of products dispo sed because of expired products is 14 for Instance 2-1 representing that the retailer does not discount the price at all. And this number decreases to 2 in Instance 2-2, and no product is disposed of because of wastage from Instance 2-3 to 2-5. When s =

9, the number of product disposed because of unsold is 1 for Instance 2-1, and no product was disposed because of unsold from instance 2-2 to 2-9. Further, when s = 5 and 9, 26 and 8 more products are sold by comparing Instance 2-1(NS = 5095) with Instance 2-5(NS = 5121) for s = 5, and Instance 2-1(NS = 5115) with Instance 2-9(NS = 5123) for s = 9, respectively. Although this represents a slight improve ment, the positive effects of an earlier discount for perishable foods are more significant when the length of shelf-life is shorter.

Lastly, when i = 80, representing a situa tion in which the target inventory level exceeds the demand for a specific perishable food, the positive effects of earlier price discounting for perishables on product sold and product disposed because of unsold are higher than that with i = 60. Table 2 shows that the number of products sold increases and the number of consumers leaving decreases as the retailer start price discoun ting earlier. Specifically, when s = 5 and 9, 75 and 52 more products are sold by comparing Instance 3-1(NS = 5321) and Instance 3-5(NS = 5396) for s = 5 and Instance 3-1(NS = 5345) and Instance 3-9(NS = 5397) for s = 9, respectively. Further, a price discount for perishable foods can significantly reduce the number of disposed products due to unsold. When s = 5, the number of products disposed because of unsold is 306 for Instance 3-1, and this number decreases to 146 and 5 for Instances 3-2 and 3-3, respectively. No products are disposed due to unsold in Instances 3-4 and 3-5. When s = 9, the number of products disposed because of unsold is 143 for Instance 3-1, and this number decreases to 100, 40, and 3 for Instances 3-2, 3-3, and 3-4, respectively, and no product is disposed in Instances 3-5 to 3-9. Therefore, retailers can expect more positive effects of an earlier discount for perishable foods that have relatively shorter shelf-life. However, it should be noted that although the target inventory level and demand for foods are the same, the number of products disposed because of unsold can be higher for a product with a relatively shorter shelf-life due to a shorter sales period.

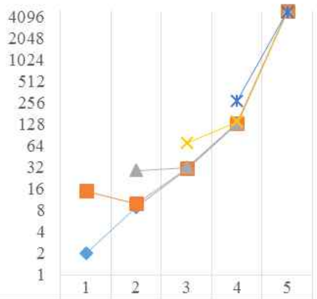
4.2 The Effects of Discount Startingtime on Inventory Aging

This sub-section evaluates the effects of discount starting time on inventory aging by comparing the number of products sold against different remaining shelf-life at the point of purchase. First, when i = 40, almost every product is sold when the full remaining days of shelf-life left for all instances for both s= 5 and 9. In this case, it is not necessary to discount the price at all when demand significantly exceeds supply of perishable food products because the price discount has no effect on inventory aging.

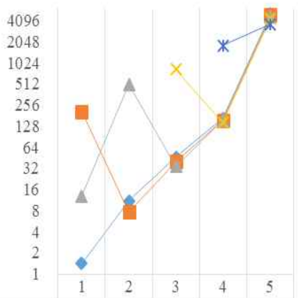
Figures 2 and 3 show that for every instance for both s = 5 and 9, more products are sold with a day remaining that is discount starting point compared to other instances(e.g., when s = 5, the number of products sold with 3 days remaining for Instance 2-4 is significantly higher than that with other instances), and it is logical with the need-driven scenario.

As Figure 3 shows, when i = 60 and s = 5 earlier discount can help mitigate the aging of the inventory. For Instance 2-5, in which the discount starts from 4 days remaining, all of the products are sold with 4 or 5 days of remaining shelf-life with no product disposed due to unsold(see Table 2). For Instance 2-4, all of the products are sold with 3 or more remaining days, ⋯, for Instance 2-1, all of the products are sold from 1 day remaining. For Instances 2-1 and 2-2, the products are sold from with 1 day remaining, and the number of products sold with 1 day remaining is higher for Instance 2-2 then Instance 2-1, but it is noticeable that the number of disposed products is higher for Instance 2-1 than that for Instance 2-2.

An earlier discount can also help retailers mitigate inventory aging when i = 80 and s = 5. For Instance 3-5, all of the products are sold with 4 or 5 days remaining shelf-life. For Instance 3-4, all of the products are sold with 3 or more days remaining shelf-life, while Instances 3-1 to 3-3 the products are sold from with 1 remaining day of shelf-life.



	1	2	3	4	5
Instance 2-1	2	9	30	132	4923
Instance 2-2	15	10	31	134	4914
Instance 2-3		29	32	135	4913
Instance 2-4			70	141	4903
Instance 2-5				276	4844



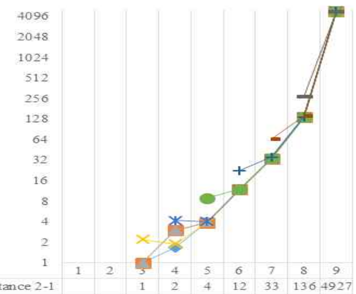
	1	2	3	4	5
Instance 3-1	1	11	46	164	5098
Instance 3-2	205	8	40	154	4932
Instance 3-3	13	500	34	154	4660
Instance 3-4			824	143	4412
Instance 3-5				1784	3612

〈Figure 3〉 The effects of starting time for discount on inventory aging, $s = 5$

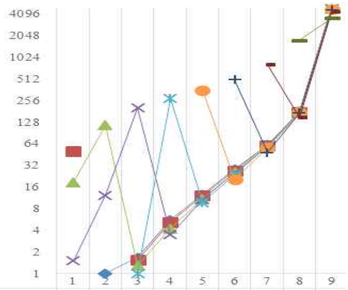
Note: In the figures, Y-axes represents the number of product sold and X-axes represents the remaining days of shelf-life at the point of purchase

When comparing Instances 3-2 and 3-3, the number of product sold with 1 remaining day of shelf-life and the number of product because of unsold products is significantly higher for Instance 3-2(i.e., 205 and 146, respectively) than for Instance 3-3(i.e., 13 and 5, respectively) as indicated in Figure 3 and Table 2. For Instance 3-1, it looks like inventory is less aged comparing to Instances 3-2 and 3-3, but the number of products disposed for Instance 3-1(i.e., 306) is significantly higher than that for Instances 3-2 and 3-3. In this simulation, consumers purchase the products that with fresher condition for Instance 3-1 than for Instances 3-2 and 3-3, but it can be said that from the retailers' perspective the products are more aged for Instance 3-1 with significantly higher number of product disposed.

In addition, an earlier discount slightly helps the retailer to mitigate the inventory aging when i = 60 and s = 9. However, the positive effects of earlier discount on inventory aging are feeble. On contract, when i = 80 and s = 9, there are more significant positive influence of earlier discount, using the same logical analysis as for i = 80 and s = 5. For example, when comparing Instances 3-1 and 3-2 for s = 9, 51 products are sold with 1 day remaining shelf-life for Instance 3-2 and no product was sold with 1 day remaining shelf-life for instance 3-1, on the other hand, from the retailer's perspective, there is significantly higher number of product disposed due to unsold for instance 3-1(i.e. 143) than that for instance 3-2(i.e., 100). Therefore, from the retailer's perspective, it can be said that



	1	2	3	4	5	6	7	8	9
Instance 2-1			1	2	4	12	33	136	4927
Instance 2-2			1	3	4	12	33	136	4927
Instance 2-3			1	3	4	12	33	136	4927
Instance 2-4			2	2	4	12	34	137	4927
Instance 2-5				4	4	12	34	136	4927
Instance 2-6					9	12	34	137	4926
Instance 2-7						23	35	138	4924
Instance 2-8							66	144	4911
Instance 2-9								274	4848



	1	2	3	4	5	6	7	8	9
Instance 3-1		1	2	6	13	28	62	181	5053
Instance 3-2	51		2	5	12	27	61	177	5013
Instance 3-3	19	117	1	4	11	26	58	177	4945
Instance 3-4	2	12	203	3	11	25	59	177	4871
Instance 3-5			1	272	10	24	60	177	4826
Instance 3-6					357	21	56	176	4769
Instance 3-7						503	48	172	4661
Instance 3-8							815	150	4426
Instance 3-9								1783	3614

〈Figure 4〉 The impacts of starting time for discount on inventory aging, $s = 9$

Note: In the figures, Y–axes represents the number of product sold and X–axes represents the remaining days of shelf–life at the point of purchase earlier discount can help to mitigate inventory aging when the aimed inventory level is significantly higher than demand for a specific perishable food with 9 days of shelf-life.

Ⅴ. Conclusion

Using simulation tests, we evaluated the effects of price discount starting time for perishable foods on retailer performance, focusing on sales volume, wastage because of unsold products, and the inventory aging. This study presents valuable practical implications and academic contributions that enhance understanding of the value of earlier price discounts for perishable foods as follows.

5.1 Practical Implications

With the simulation results above, this paper provides several practical implications to retailers who wish to improve the retailer performance, using the differentiated pricing policies by the demand type of perishable food products. First, for a specific perishable food product for which the average demand normally exceeds supply, an earlier price discount does not benefit retailers in terms of sales, wastage because of unsold, or inventory aging. In this case, food retailers do not need to discount the price for perishable foods because demand significantly exceeds supply. Second, in general, for a specific perishable food product for which the average demand nearly equals the supply(e.g., perishable foods that retailers could predict the demand accurately), an earlier price discount can slightly enhance sales volume. Retailers can also expect reduction of wastage by price discounting compared to when they do not discount the price at all. Furthermore, the positive effects of a price discount on wastage reduction are higher for a product with relatively short shelf-life. For inventory aging, retailers can expect significant positive effects from an earlier price discount for a perishable food with a relatively short shelf-life(5 days of shelf-life in our case context). Conversely, the positive effects of earlier price discount are weak for a perishable food with relatively longer shelf-life(9 days of shelf-life in our case context). Lastly, for the case of which the average supply normally exceeds demand(e.g., perishable foods for which retailers often fail to predict the demand, and whose inventory levels are over-targeted), retailers can expect positive effects from an earlier price discount, mitigating the inventory aging of perishable foods that have relatively shorter and longer shelf-live.

In summary, we propose that retailers should discount the price earlier but in smaller rates(considering the amount of value deteriorated as the remaining days pass) for perishable foods. This is particularly true for products for which retailers can accurately predict the average demand or whose average supply normally exceeds demand, leading to increased sales, decreased wastage, and reduced inventory aging. However, for specific perishable foods that have relatively long shelf-lives and retailers predict the average demand accurately, the positive effects of earlier discount are limited.

5.2 Academic Contributions

It has been noted that inventory aging influences consumer confidence for perisha ble foods(Sarker, Mukherkee and Balan 1997), and perishable foods significantly influence retailer business performance. However, prior studies on the pricing of perishable foods(Li, Tang, O'Brien and Wang 2006; Liu, Tang and Huang 2008; Wang and Li 2012) were focused on investigating the optimal pricing structure for perishable foods when more accurate product quality can be identified. And using simulation tests, a recent study investigated the value of more dynamic pricing for perishable foods which can improve retailer performance in terms of profits, sales volume and wastage(Chung and Li 2013b). However, the study has not focused on the inventory aging. By evaluating the value of earlier price discount for perishable foods, this study gives researchers a better understanding of the relationships between discount starting time of perishable foods and retailer performance including sales, wastage and inventory aging. In addition, this study enables to identify further studies considering the limitations of the study as follows.

5.3 Limitations

This study has several limitations. Although we show the general effects of an earlier price discount on retailer perfor mance, we have not shown the optimal time and rate of price discount to maximize the profitability of perishable foods. Using simulation model of this study that was built based on the model of Chung and Li(2013b), it is difficult to show the impacts of discount starting time on profitability of perishable foods as the profitability will be varied depending on the rate of discounts applied to the simulation model. Therefore, further studies focusing on the optimal discount starting time and rate of perishable foods using various mathematical assumptions can contribute academia and industry.

In addition, in our simulations, every consumer follows their own need-driven scenarios when they make a purchase. However, not every consumer behaves rationally when purchasing perishable foods. Some consumers always purchase the product with the longest remaining shelf-life, whereas others always purchase the product with the lowest price but shorter remaining shelf-life. Finally, some consumers are not likely to check the expiration date, and purchase products randomly. Further, we have not compared the optimal discount rate against different remaining shelf-life that consumers can generally accept and are willing to make trade-offs the price against remaining shelf-life. Further studies investigate these issues will provide a better understanding of the positive effects of an earlier discount for retailers.

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References

Aviv, Yossi and Amit Pazgal(2008), "Optimal Pricing of Seasonal Products in the Presence of Forward-Looking Consumers," *Manufacturing & Service Operations Management*, 10(3), 339-359.

Bitran, Gabriel R. and Susana V. Mondschein(1997), "Periodic Pricing of Seasonal Products in Retailing," *Management Science*, 43(1), 64-79.

Chung, Jaekwon and Dong Li(2013a), "The Prospective Impact of a Multi-Period Pricing Strategy on Consumer Perceptions for Perishable Foods," *British Food Journal*, 115(3), 377-393.

Chung, Jaekwon and Dong Li(2013b), "A Simulation of the Impacts of Dynamic Price Management for Perishable Foods on Retailer Performance in the Presence of Need-Driven Purchasing Consumers," *Journal of the Operational Research Society*, advance online publication, 12 June 2013 (DOI 10.1057/palgrave.jors.2013.63).

Dasu, Sriram and Chunyang Tong(2010), "Dynamic Pricing When Consumers are Strategic: Analysis of Posted and Contingent Pricing Schemes," *European Journal of Operational Research*, 204(3), 663-671.

Donselaar, K.H. van, T. van Woensel, R. Broekmeulen and J.C. Fransoo(2006), "Inventory Control of Perishables in Supermarkets," *International Journal of Production Economics*, 104(2), 462-472.

Elmaghraby, Wedad and Pinar Keskinocak (2003), "Dynamic Pricing in the Presence of Inventory Considerations: Research Overview, Current Practices, and Future Directions," *Management Science*, 49(10), 1287-1309.

Elmaghraby, Wedad, Altan Gulcu and Pinar Keskinocak(2008), "Designing Optimal Preannounced Markdowns in the Presence of Rational Customers with Multiunit Demands," *Manufacturing & Service Operations Management*, 10(1), 126-148.

Eom, Young Sook(1994), "Pesticide Residue Risk and Food Safety Valuation: A Random Utility Approach," *American Journal of Agricultural Economics*, 76(4), 760-772.

Ferguson, Mark and Michael E. Ketzenberg(2006), "Information Sharing to Improve Retail Product Freshness of Perishables," *Production and Operations Management*, 15(1), 57-73.

Feng, Youyi and Guillermo Gallego(1995), "Optimal Starting Times for End-Of-Season Sales and Optimal Stopping Times for Promotional Fares," *Management Science*, 41(8), 1371-1391.

Gallego, Guillermo and Garrett van Ryzin (1994), "Optimal Dynamic Pricing of Inventories with Stochastic Demand Over Finite Horizons," *Management Sciences*, 40(8), 999-1020.

Heller, Walter(2002), "55TH Annual Consumer Expenditures Study," *Progressive Grocer*, 81(13), 15-24.

Hinterhuber, Andreas(2004), "Towards Value-Based Pricing – An Integrative Framework for Decision Making," *Industrial Marketing Management*, 33(8), 765-778.

Hinterhuber, Andreas(2008), "Customer Value-Based Pricing Strategies: Why Companies Resist," *Journal of Business Strategy*, 29(4), 41-50.

Kerin, Roger A, Ambuj Jain and Daniel J. Howard(1992), "Store Shopping Experience and Consumer Price-Quality-Value Perceptions," *Journal of Retailing*, 68(4), 376-397.

Kincaid, W.M. and D.A. Darling(1963), "An Inventory Pricing Problem," *Journal of Mathematical Analysis and Applications*, 7(2), 183-208.

Levin, Yuri, Jeff McGill and Mikhail Nediak (2009), "Dynamic Pricing in the Presence of Strategic Consumers and Oligopolistic Competition," *Management Science*, 55(1), 32-46.

Li, Michael Z.F.(2001), "Pricing Non-Storable Perishable Goods by Using a Purchase Restriction with an Application to Airline Fare Pricing," *European Journal of Operational Research*, 134(3), 631-647.

Li, Dong, Ou Tang, Christopher O'Brien and Xiaojun Wang(2006), "Improved Food Supply Chains Operations by Dynamic Product Tracing," *International Journal of Services Operations and Informatics*, 1(4), 347-362.

Liu, Xiaofeng, Ou Tang, Pei Huang(2008), "Dynamic Pricing and Ordering Decision for the Perishable Food of the Super market Using RFID Technology," *Asian Pacific Journal of Marketing*, 20(1), 7-22.

Rajan, Arvind, Rakesh Steinberg and Richard Steinberg(1992), "Dynamic Pricing and Ordering Decisions by a Monopolist," *Management Science*, 38(2), 240-262.

Sarker, Bhaba R., Subhasis Mukherjee and Chidambaram V. Balan(1997), "An Order-Level Lot Size Inventory Model with Inventory-Level Dependent Demand and Deterioration," *International Journal of Production Economics*, 48(3), 227-236.

Shapiro, Benson P. and Barbara B. Jackson (1978), "Industrial Pricing to Meet Customer Needs," *Harvard Business Review*, November, 119-127.

Su, Xuanming(2007), "Intertemporal Pricing with Strategic Customer Behaviour," *Management Science*, 53(5), 726-741.

Tsiros, Michael and Carrie M. Heilman(2005), "The Effect of Expiration Dates and Perceived Risk on Purchasing Behaviour in Grocery Store Perishable Categories," *Journal of Marketing*, 69(2), 114-129.

Wang, Xiaojun and Dong Li(2012), "A Dynamic Product Quality Evaluation Based Pricing Model for Perishable Food Supply Chains," *Omega*, 40(6), 906-917.

신선식품의 가격할인 시점이 식품 소매업자의 성과에 미치는 영향

정재권*, 최대헌**, 박일진***

신선식품(perishable foods)은 짧은 유통기한과 시간의 흐름에 따른 가치하락을 지니고 있는 식품군으로써, 이는 식품 소매업계의 매출과 경쟁력에 중요한 영향을 미치고 있다. 이러한 중요성에도 불구하고, 신선식품의 속성상, 다른 제품에 비해 복잡한 가격결정 프로세스를 지니고 있음으로, 식품 소매업자들은 신선식품의 가격정책 수립에 있어서 많은 어려움에 직면하고 있다. 대부분의 신선식품은 유통기한의 만료가 가까워질수록 신선도의 저하로 인해 제품의 가치가 하락하는 특성을 지니고 있다. 이러한 신선식품의 특성은 고객의 구매의도에 영향을 미치고 있으며, 이는 식품소매업자의 성과에 직간접적으로 영향을 미치고 있다. 그러므로 식품소매업자는 유통기한이 다가옴에 따른 신선식품의 가치하락에 대한 손실을 보상할 수 있는 적절한 가격정책의 수립을 통해 매출을 증가시키고, 폐기량을 줄이며, 재고의 노화(inventory aging)를 완화시켜야 할 것이다.

선행연구에서 시간의 흐름에 따라 가치를 상실하는 제품(perishable products)의 최적 가격정책 모형에 관한 많은 연구가 이루어졌다. 하지만, 가격인하시점이 유통업자의 성과에 미치는 영향에 관한 논문은 거의 없다. 따라서 이 논문에서는 신선식품의 각기 다른 가격인하 시점이 식품소매업의 성과지표에 어떤 영향을 미치는지 시뮬레이션 모델을 통해 분석하였다. 분석 결과, 이 연구는 식품소매업자의 신선식품의 빠른 가격인하정책(earlier price discount)이 매출을 향상시키고, 유통기한이 지남에 따른 제품의 폐기량(wastage due to unsold products)을 감소시키며, 그리고 재고의 노화를 완화시키는 등 긍정적인 영향을 주고 있음을 보여준다.

주제어 : 신선식품, 재고의 노화, 식품 가격, 식품 소매업

* 제1저자, 국민대학교 경영대학 (jchung@kookmin.ac.kr)
** 교신저자, 국민대학교 경영대학 (dhchoi@kookmin.ac.kr)
*** ㈜ 조이시티 (iljin7432@hotmail.com)