Improving the Storage of Some Food Categories to Reduce the Irretrievable Losses of a Retailer: Methodology Analysis

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Abstract. Retailers conventionally store perishable foods in refrigerated display cases to keep them at specific temperatures; air conditioning dries the air in the room, which in turn causes these foods to lose moisture. Water as a dispersing medium and a solvent affects the consistency, structure, and appearance of foods in storage. However, excessive moistness will also jeopardize the quality of foods by providing fungi and bacteria with good conditions for growth. Conventional food storage technology does not involve humidity control; as a result, food appearance and quality degrades, and the intensive food drying results in excessive shrink-related costs to the retailer. To minimize the negative impact of such overdrying of perishable foods on the retailer's economy, storage facilities must provide optimal temperature and humidity. In this research, the author monitor and compare the write-offs labeled as 'defective' and the irretrievable shrink-related losses to identify and analyze the effectiveness of humidity control-enabled refrigeration units when used to store some foods categories in refrigerated display cases.

1 Introduction

Retail is one of the core economic activities in the Russian Federation. The State Committee on Statistics reports Russia's retail to grow year over year, amounting to 31.6 billion rubles in 2018, a 2.8% increase YoY. In Primorsky Krai alone, retail grew by 105,677.5 million rubles from 2015 through 2019, a sign of the industry's stable growth on the national and regional scale [1].

The quality of foods sold in today's socially oriented economy is a critical competitive advantage or disadvantage, whether for food producers or for retailers. Research on the quality and safety of foods is the subject matter of numerous papers by Russian [2,3,4,5] and international scientists [6,7]. Those that lead in quality keep taking over new markets and market segments, leaving their competition in ruins if the competitors are unable to produce foods of appropriate quality: foods that comply with law or suit the retailer's description or match the buyer's desires the retailer is aware of. These processes are further boosted by the fact that quality as part of a company's image is contributing ever more to its competitiveness and therefore to the bottom line [8]. The producer's image is an ever

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more crucial factor affecting the consumers' choice. This further multiplies the effect of a company's leadership in the quality of its goods and services. Novel quality management approaches call for the science-based betterment of all processes. Many papers [9,10,11,12,13,14 et al.] dwells upon the trends and prospects of using cutting-edge technology including IT: smart packaging, freshness indicators, and moisturization systems. Quality improvement is relevant for any for-profit company of today, as quality dictates profits.

The novelty of this research arises from the lack of experimental scientific research that tested the feasibility of adopting humidity-controlling modules for retail refrigeration units to improve storage, and therefore to reduce the retailers' shrink-related losses.

The goal hereof was to calculate and analyze the cost-effectiveness of adopting humidity-maintaining equipment to store foods show shrink exceeds the regulatory values, which foods are stored in retail refrigerators without using individual consumer packaging.

As part of this study, the author ran self-audit and performance assessment of the quality management system at a major retail center using Ye.V. Meshchzrekova's methodology; this effort revealed multiple issues including non-compliance with the humidity recommendations for perishable foods. Failure to keep perishable foods at proper humidity caused premature spoilage leading to write-offs labeled 'defective' and high shrink-related losses. As part of this research, the author developed an investment project that sought to improve the existing quality management system by adopting novel equipment designed to keep optimal humidity of some refrigerated foods by irrigating these foods so as to reduce irretrievable losses. To implement this project, the retailer was asked to equip its refrigerated display cases where perishable foods of the highest shrink rate were stored with high-pressure irrigation nozzles. Compared to functionally similar solutions, this equipment would be easier to install, require no maintenance in continuous operation, and would cause no precipitation on foods, hence the choice.

The project was implemented successfully in January 2019; Step 1 was to equip refrigerated display cases with the author-proposed equipment, specifically the cases that were used for storing food categories that had the greatest difference between the normal shrink rate (set forth in the Order of the Russian Ministry of Industry and Trade No. 252 dd. March 1, 2013) and the actual shrink rate found by scheduled stock counting in 2018, see Table 1. In the retailer's product accounting system, foods subject to such improved storage was split into different subgroups: fish foods, and fruits and vegetables. It should be noted that being weakly resistant to mechanical damage, these foods were stored unpackaged.

Table 1. Actual and normal daily shrink rates for fruits, vegetables, and fish foods prior to the adoption of the author-recommended equipment, 2018.

Shrink per day (S)	**Fish foods, %**		**Fruits and vegetables, %**	
	Normal	**Actual**	**Normal**	**Actual**
Stored in refrigerated display cases	0.28	2.5	0.8	2.7

The normal shrink rate for fruits and vegetables was calculated by the retailer as the mean of the standard shrink rates for the whole set of fruit and vegetable items subject to storage in refrigerated food cases to be upgraded; the standard rates were taken from the Order of the Russian Ministry of Industry and Trade No. 252 dd. March 1, 2013 and adjusted for each item's turnover period and share.

The normal shrink rate for fish was calculated by the retailer as the mean of the standard shrink rates for the whole set of gastronomy items subject to storage in refrigerated food cases to be upgraded; the standard rates were taken from the Order of the Russian Ministry

of Industry and Trade No. 252 dd. March 1, 2013 and adjusted for each item's turnover period and share.

Actual shrink rates were calculated from the stock counting reports for 2018.

As shown in Table 1, the retailer's shrink-related loss was 8.9 times higher for fish, 3.4 times higher for fruits and vegetables compared to the normal values, which undoubtedly had a negative impact on the costs and on the retailer's economy.

2 State of the art

Multiple studies analyze how storage conditions including the relative humidity affect food drying and retailers' economic performance, see Yu.A. Mironchuk, V.P. Chepurenko [15,16], Ye.N. Neverova [17, 18, 19], T.V. Pershakova, G.A. Kupin, A.S. Borodikhin, V.N. Aleshin [20] et al. Manufacturers and vendors of humidity control equipment for refrigerated display cases claim their machinery is very efficient; however, the authors have not found any experimental research that would support that claim in the context of retail.

3 Research

The classical definition of cost-effectiveness is maximizing the benefits of using the available resources [21]. It can be measured by return on assets, profitability, payback, return on investment, etc. Two indicators are used to measure the cost-effectiveness of investment: the economic benefit and profitability. Profitability is the ratio of economic benefit to the investment it took to achieve, see Equation 1. If the profitability is below 25%, the proposal is deemed unfeasible [22].

$$(E / D)*100\% = EF \tag{1}$$

In a broader sense, economic benefit is the difference between the outcomes of any activity of a business and the costs of reaching these outcomes. Economic benefit is there if the added profit exceeds added costs. In this study, the economic benefit was calculated by counting the difference between the added costs and added profits of a retailer associated with implementing the equipment adoption project, see Formula 2.

$$D - C = E \tag{2}$$

To reduce irretrievable shrink-related losses, two refrigerated display cases where foods of the earlier specified subgroups were stored without individual packaging (greens, fruits, berries, smoked fish, etc.) were equipped with high-pressure irrigation nozzles. This equipment is designed to serve for at least three years, and the manufacturer provides gratis warranty services over this entire period.

Table 2 shows the structure and the total of the costs associated with attaining the economic benefit (C) under this investment project. Added annual profits were calculated by the Equipment 3 as the difference between the 'defective' write-offs (S) and irretrievable losses (Y) in either food category before (S1,Y1) and after (S2,Y2) the equipment was adopted (2018 and 2019, respectively). Equipment purchase and commissioning accounted for the greatest portion of the costs. Payroll had to be raised because the quality specialist's duties were expanded, as they were now tasked to keep the intra-refrigerator humidity within the specified limits and to develop corporate guidelines on how to operate this new equipment; thus, the specialist's paycheck for 2019 had to be increased as well. Besides, the quality specialist needed additional training to utilize this new equipment. Thus, Table 2 shows the added costs of 390,000 rubles associated with attaining the projected economic benefits.

Table 2. Investment structure, 2019.

Expenditure	Amount, rubles	Percentage
Personnel raining	10,000	2.6
Payroll increase	60,000	15.4
Equipment purchase, transportation, and installation	320,000	82
Equipment maintenance	0	0
Total	390,000	100

$$(\Sigma S1 - \Sigma S2) + (\Sigma Y1 - \Sigma Y2) = D \quad (3)$$

To find the actual added annual profit associated with adopting this new equipment, the researchers monitored and compared the retailer's shrink-related losses and write-offs labeled 'defective' for the food subgroups stored in the upgraded equipment; the values were collected for periods before and after the upgrade.

Adding the irrigation system reduced the 'defective' write-offs of fruits and vegetables from 24% to 19% and those of fish from 20% to 13.5%. This effectively reduced the retailer's losses by 219 thousand rubles.

Figure 1 shows the curve of irretrievable shrink-related losses on fish as revealed by the retailer's scheduled stock counts before and after modifying the refrigerated display case. Notably, the purchase of fish in natural terms only rose by 0.07% in 2019 YoY.

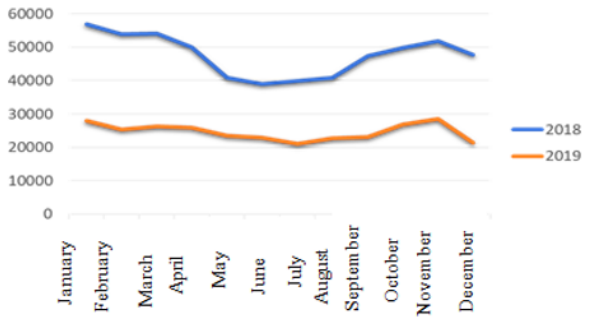

Fig. 1. Irretrievable shrink-related losses on fish, rubles.

Improving the fish storage by maintaining the relative optimal humidity of 75% reduced by irretrievable losses in 2019 by 71.1% YoY, which saved the retailer 280,639 rubles.

Figure 2 shows the curve of irretrievable shrink-related losses on fruits and vegetables as revealed by the retailer's scheduled stock counts before and after modifying the refrigerated display case. Notably, the purchase of fruits and vegetables in natural terms only rose by 0.02% in 2019 YoY.

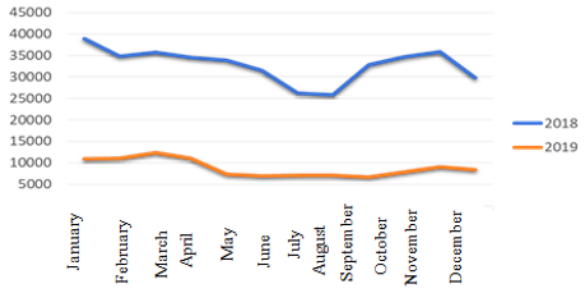

Fig. 2. Irretrievable shrink-related losses on fruits and vegetables, rubles.

Improving the fruit and vegetable storage by maintaining the relative optimal humidity of 85% reduced by irretrievable losses in 2019 by 48.3% YoY, which saved the retailer 276,223 rubles.

Therefore, this research proves that a keeping the optimal humidity in the retailer's refrigeration equipment helps reduce irretrievable losses by lowering the shrink-related losses and 'defective' write-offs, which in turn is attributable to the prevention of excessive food drying.

Table 3 shows the data that was used to calculated the added annual profits.

Table 3. Change in the irretrievable losses on fruits, vegetables, and fish foods before and after adopting the new technology.

Total irretrievable losses due to shrink, rubles			
	2018	**2019**	**Total**
Fruits and vegetables	571,834	295,611	966,513
Fish foods	394,679	114,040	409,651

Thus, the added profit of adopting the optimal humidity maintenance equipment for storing perishable fruits, vegetables, and fish foods sold without individual packaging totaled 775,862 rubles per Equation 3. The project paid off and prove highly profitable.

Table 4 shows the calculated economic benefits of this investment project for 2019 per Equation 2, which totaled 385,862 rubles.

Table 4. The economic benefit and cost-effectiveness of the project for the first year, rubles.

Year of operation	**Added profits, rubles**	**Added costs, rubles**	**Economic benefit, rubles**	**Cost-effectiveness, %**
2019	775,862	390,000	385,862	98

Thus, experimental data (Table 4) used to calculate how cost-effective the enhanced food storage system was show its cost-effectiveness was 98% over the first year per Equation 1.

Besides, the author have projected further economic benefits and cost-effectiveness of the project for two more years of the equipment service life excluding some of the added costs from Table 2, namely personnel training, purchase, transportation, and installation; see Table 5 for the results. Product hydration systems are auxiliary equipment for refrigeration units used in retail; they are designed to minimize the impact of dry air on the retailer's costs attributable to quality loss and perishability.

Table 5. Economic benefit and cost-effectiveness projection for post-implementation years.

Year of operation	**Added profits, rubles**	**Added costs, rubles**	**Economic benefit, rubles**	**Cost-effectiveness, %**
2020	775,862	133,333	642,529	481
2021	775,862	133,333	642,529	481

4 Research results

The experimental findings are: the calculated economic benefits and cost-effectiveness of implementing high-pressure irrigation nozzles to moisten foods sold without individual packaging; the proven effectiveness of this enhanced storage method for some food categories as an irretrievable loss reduction tool for the retail industry.

This research is of applied nature; the experiment has valuated the economic benefits and cost-effectiveness of upgrading refrigerated display cases used in retail with irrigation systems.

Experimental research data could be of use for authoring guidelines on assessing the effectiveness of the tested equipment for use in retail so as to help managers decide whether to adopt similar technologies; such guidelines could also be useful for further research in the area.

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