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Analysis of Pest Prevention Packaging Cases in Preparation for Consumer Complaints Caused by Global Warming in the Product Distribution Process: Focusing on Poly Bag Packaging for Hygiene Products in Company A

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Abstract The present study was conducted to accomplish management efficiency by preparing preemptive measures for consumer dissatisfaction and overcome risks caused by Global Warming through studies of model cases in packaging. Through this study, we made it possible to find a way for companies to prepare for Global warming and consumer dissatisfaction. By contributing to eco-friendly packaging, we are trying to preemptively respond to recent major issues through packaging. Through this experiment, we tried to measure the degree of penetration of *Plodia interpunctella* H. larva into the insect repellent film produced by printing Ink containing a natural repellent. The control experiment was conducted with an untreated LDPE film to which no insect repellent was applied. The numbers decreased from 17 to 7 when the film was processed with repellent to show experimental results verifying effects of repellent by decrease in 10 (58.8% Decrease). Such results show that it is safe when the film is unfolded but in the case where the film is folded, the *Plodia interpunctella* H. punches through the film to lead to consumer dissatisfaction and it suggests that this can bring on risks to corporate management. Considering that most of the film is folded in the case of PE bag packaging, the direction which the corporations should take in terms of preparing for climate change countermeasures and consumer dissatisfaction has been clarified. Due to it receiving satisfactory results in safety rest results for printing film applied with pest repellent as well as the Quality analysis to test repellent contents of repellent film, it is certain that the importance of repellent method in packaging will increase in preparing for consumer dissatisfaction and actions against climate change henceforth.

Keywords Global warming, Consumer complaints, Pest prevention packaging cases, PE bag packaging

Introduction

With the development of new consumer trends in accordance with the recent economic, cultural and social factors, the distribution environment has entered the age of limitless competition with no boundaries between channels due to technological developments, entry of various channels and changes in consumption patterns[1,2]. Especially, as 4th industrial revolution began, development of new products through technical innovation is an important topic amongst corporations. The development of new products through such technical innovations is ultimately for customer satisfaction and as the products are more customer-oriented, the voluntary acceptance of consumers is increased[3]. Moreover, the definition of customer satisfaction can be viewed as feeling of satisfaction that exceeds the expectation for the product or the emotional response that can be gained through product consumption[4,5]. In short, customer satisfaction evaluates the level of service based on the consumer's expectations and the disharmonious experience. And when the experience is rated higher than their expectation, the customer is further satisfied and the satisfying experience forms positive images for the relevant corporation or the product[6].

This along with the numerous phenomena of climate change caused by global warming, are placing great influence on our daily lives through economical and non-economical paths[7]. With the start of the 21st century, natural disasters are occurring often through climate change all over the world and the changes in the ecosystem in accordance with the natural disasters have caused changes in the human lives and activities. Furthermore, climate change has been forewarning overall changes to corporate management since after 2000. Due to the influence of abnormal climate through climate change, corporations are finding risks and opportunities of management and studies are being conducted to find preventative

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measures and management crisis response strategy for abnormal climate to enhance competitive power[8]. Weather anomaly in accordance with climate change is influencing each industry and this is providing growth opportunities of the industries according to new market developments and development of new products. On the other hand, warm humidification of earth is not only causing increase in activity time and breeding activities of harmful insects but also causing rapid increase in population of harmful insects to gradually increase the possibilities of being contaminated with filths by animals during the distribution process[9].

Thus, the studies on consumer complaining behaviors of consumers are being actively conducted[10-17] and various definitions of the consumer complaining behaviors are being presented[18-22]. In terms of trust, immersion, loyalty, positive word of mouth activities and repurchase intentions regarding corporations, the successful results of complaint handling services have positive influence on the awareness and attitude of consumers[23-29]. Meanwhile, the insincere measures taken by businesses during the complaint handling process will worsen the relationship between the business and consumer and bring results where the consumers will evaluate the business with more negativity after experiencing the complaint handling service than right after experiencing the initial act that led to the complaint[30-35]. In short, the process of handling consumer dissatisfaction is not an additional service that is simply accompanied with providing goods and services but a domain of an important core strategy and can be defined as a very important moment of truth for the development and maintenance of a favorable relationship between the consumer and the business[36-37]. In such ways, management capacity of systematic management for critical situations that occur within the corporations such as preemptive measures for consumer dissatisfaction and actions against climate change are deemed necessary in addition to the management strategies that aims to increase sales. Therefore, climate change crisis management including climate change and consumer complaints should be considered for the broad range of consumer distribution processes such as demand forecast, product development, purchase, logistics, delivery, packaging, inventory management, and store operation.

Within this ever-changing situation, packaging is the field that should receive the most attention. Pain[38] stated “packaging is the art, science and technique of product that is prepared for transport or sales” and the UK’s Institute of Packaging(IOP) have defined packaging as “the technique and process of the preparations that are attempted to ship, store and ship products or items to consumers.”[39] Moreover, with the two phrases of packaging being “the silent salesperson” and “plays the role of selling products” in the modern society, it was expressed that packaging is appearing as a powerful weapon on the sites of sales. In short, the present study was conducted based on the actual case of the manufacturer A’s hygiene products and by analyzing this case, the study can serve as the foundation of process that contributes to the management efficiency of corporations and also determined to have practical value. The main content of this study is to compare and analyze the pest invasion inhibitory effect of products treated with pest intrusion inhibitors and the possibility of invading pests from existing packaging. We tried to find out the possibility of application to actual industrial sites through sample production using a gravure printing machine.

Study Procedure and Methods

1. Study Procedure

The present study was conducted to accomplish management efficiency by preparing preemptive measures for consumer dissatisfaction and overcome risks caused by climate changes through studies of model cases in packaging. In the recent times, the world has taken a new turn that is management of hygienic insect pests due to increase of various diseases caused by disease mediating insects with urban concentration of population, crowding in residential areas and turning mountainous areas into housing regions as well as inflow of insects including mosquitoes and diseases from foreign countries cause by increase in travel due to advancements in means of transportation and birds that fly in from other countries and global warming[40-42].

The most widely used pest repellent today is a product containing N,N-diethyl-3-methylbenzamide or N,N-diethyl-m-toluamide (DEET) [43], and is sold in various forms of formulation containing DEET as an active ingredient[44]. “Repellent” is a drug used to prevent invasion of harmful animals or pests by formulating chemicals in an appropriate manner which disliked and avoided by insects, and it does not have insecticide power itself.[45] Products containing essential oils such as Basil, Citronella, Cedar, Cinnamon, Fennel, Garlic, Geranium, Lavender, Rosemary, Thyme, Pennyroyal, Peppermint, Pine, and Verbena are commercialized as repellents[46-49]. In Korea, the Korean abbreviations are classified into Cinnamon Bark, Cinnamomum Cortex, Cinnamomi Cortex Spissus, Cassiae Cortex Interior, and Cinnamomi Ramulus. Cinnamomum Cassia Blume grown in China has a strong smell of herbal medicine.

As a component of cinnamon that has been discovered so far, it refers to Cinna-momic aldehyde, which is the main component of cinnamon essential oil, and is also known as a substance representing the medicinal properties of cinnamon. Cinnamon contains 1 to 3% essential oils, and the flavor varies depending on the essential oil content and composition of ingredients. In particular, the cinnamon scent ingredient sprays harmful bacteria like antibiotics. If cinnamon scent is used well, it is effective in reducing the number of pests by bring-

ing sexual confusion, olfactory confusion, and taste confusion to pests. While natural repellents have the effect of paralyzing the nervous system of insects, they do not affect mammals, including humans[50-51].

Therefore, in this study, a case study was conducted in which a manufacturer A company achieved results by using natural repellents rather than pesticides in the packaging of hygiene products. Through this study, we made it possible to find a way for companies to prepare for climate warming and consumer dissatisfaction with many social issues. By contributing to eco-friendly packaging, we are trying to preemptively respond to recent major issues through packaging.

2. Study Method

This study is to study the case of preparing for global warming and consumer dissatisfaction through packaging improvement, focusing on manufacturer A's hygiene products. In the case of general pests, it is common to infiltrate into the food through the surface of the packaging material that is already damaged, such as torn or perforated. However, *Plodia interpunctella* H. larva, unlike other pests, has a sharp and strong jaw, so it has an ability to penetrate through the intact packaging material and invade into the packaging[52].

For this reason, this study is a case of developing insect repellent packaging for *Plodia interpunctella* H. larva, not for general pests. In addition, in this study, a natural repellent was not used for the LDPE film material, and a natural repellent was used in the printing ink to increase the insect repellent effect through printing. Since the film material is not changed, it does not affect the product production process, and the purpose is to obtain the efficiency of the advantage that it is easy to apply because it is an insect repellent effect through printing only.

Through this experiment, we tried to measure the degree of penetration of *Plodia interpunctella* H. larva into the insect repellent film produced by printing Ink containing a natural repellent. The control experiment was conducted with an untreated LDPE film to which no insect repellent was applied. The natural repellent was a liquid repellent (NIRL-H-YK) developed by HIPOS R&C, and NIRL-H-YK extracted cinnamon and other edible herbs using Pretanol A for food additives and distilled water. It features no additives or artificial chemicals other than herbal extracts. All experimental products and materials were provided by manufacturer A, and other specific experiments using NIRL-H-YK were conducted by HIPOS Research & Consulting.

It is to achieve the effect of insect-repellent packaging by printing through Ink added with NIRL-H-YK, and the effect of inhibiting the invasion of pests into the PE Bag packaging of LDPE 35 μm thick was tested. The production of products treated with pest intrusion inhibitory substances was divided into insect-repellent packaging (3% of insect-repellent substance-treated packaging products) and conventional packaging (packaging products that are not treated with insect-repellent substances). In both the insect-repellent packaging and the conventional packaging, samples of packaging companies A was classified and tested for comparison and analysis. 150 worms used in the experiment were *Plodia interpunctella* H. larva, and the experimental conditions were 25-32°C room temperature and 60-70%Rh condition.

In order to achieve the purpose of the experiment, the product treated with insect repellent material and the existing product were marked, mixed, and put into an experimental container. 150 *Plodia interpunctella* H. larva raised with artificial feed were stored at 25-32°C and 60-70% RH for 7 days, and then the number of populations found outside the packaging of the finished product, crevices and inside the product was investigated. After placing a film on the middle layer of the production container, 3 *Plodia interpunctella* H. on the upper layer and 9 experimental environments with food on the lower layer were created. After that, the film was stored in a constant temperature and humidity chamber at 28°C, 60~70% RH for 3 days, and the film was observed. Through the number of pupa and larva found in the product, the results of the mixed injection test of the film of packaging company A could be confirmed. Statistical processing according to the experimental results was verified at the 99% level through T-Test and ANOVA.

Results and discussion

1. Result of Mixed Injection Test of Film of Packaging Company A

As a result of investigating the number of pupa and larva found in the product to investigate the attraction-inhibiting effect of repellent substances, the outer surface of the pavement was $df = 30$, $t = 5.73$, $P < 0.0001$, and the gap outside the pavement was $df = 30$, $t = 2.66$, $P = 0.0124$. In addition, it was

Table 1. Film test results of packaging company A

Division	External printing surface	External gap (unprinted part)	All outside (gap + surface)	Population outside the bag
No insect repellent treatment				$df = 30$, $t = -8.51$, $p < 0.0001$
Insect repellent treatment	$df = 30$, $t = 5.73$, $p < 0.0001$	$df = 30$, $t = 2.66$, $p = 0.0124$	$df = 30$, $t = 4.15$, $p = 0.0003$	$df = 30$, $t = -4.20$, $p = 0.0002$

analyzed that there was a statistically significant difference in the number of individuals found at $df = 30$, $t = 4.15$, and $P = 0.0003$ outside the packaging at the significance level of 99% between treated and untreated products with insect repellents. The number of individuals found outside the bag is $df = 30$, $t = -8.51$, $P < 0.0001$ for products treated with insect repellent materials, and $df = 30$, $t = -4.20$, P=0.0002 for existing products not treated with insect repellent materials. All were significantly observed in the gaps on the unprinted surface. On the other hand, invasion into the product due to perforation was found only in the finished product untreated with insect repellent material, but the number of individuals found inside was not statistically significant ($df = 30$, t =1.00, P = 0.3253).

2. Film Perforation Test Result of *Plodia Interpunctella*

This time, a perforation test of the film without insect repellent material and the film with insect repellent treatment was conducted, and an independent space was formed by installing a PE film of 35 μm thick LDPE printed with existing products and insect repellent materials in the container manufactured for this experiment. Three experimental worms were placed in the upper part of each independent space, and observed for 3 days after the injection to investigate the non-woven material of PE film. As a result of the experiment by mounting the PE film for each test in the unfolded state in the middle layer of the perforation test container, most of the perforation was not observed because the ball of *Plodia interpunctella* H. larva did not get caught on the unfolded film surface. On the other hand, as a result of the experiment with 18 *Plodia interpunctella* H. put in the folded state of each test PE film in the middle layer of the perforation test container, most of the perforations were observed due to the easy mastication of the folded film side of *Plodia interpunctella* H. larva. <Table 2>. In the existing films of packaging companies A and B, the perforation rate is 94.4% (17), whereas in the insect-repellent films of packaging companies A and B, the perforation rate is 38.9% (7). Compared to the existing film, in the case of films treated with insect repellent, 94.4% (17 animals) to 38.9% (7 animals). These are experimental results that have proven their effectiveness.

These results imply that the film is safe in the unfolded state, but in the folded state, *Plodia interpunctella* H. leads to consumer complaints through the film perforation, which may bring a risk to corporate management. Even when the film is folded, it is confirmed that the effect of repelling pests can be significantly different through this experimental comparative analysis between the packaging of the product treated with insect repellent material and the packaging of existing products.

Table 2. Perforation test result of film folded state

Division	Existing Film of Packaging Company A	Insect Repellent Film from Packaging Company A
Sample	18	18
Perforation	17	7
Perforation rate (%)	94.4	38.9

3. Printing Film Safety Test Result and Cost Change Containing Insect Repellent Material

For safety inspection, the insect-repellent packaged bag was commissioned to Korea Conformity Laboratories (KCL) to conduct a polyethylene test. As a result of the test, it was confirmed that both the residual and dissolution tests were normal as shown in <Table 3> and <Table 4>.

For quality inspection, we measured the sealing strength of the insect-proofed Bag after packaging the product, and as a result of the inspection, As shown in <Table 5>, <Fig. 1> and <Fig. 2>, it became the same level as before. It is the result of confirming that the sealing strength of the film treated with insect repellent is normal compared to the previous one, and

Table 3. Residual test results of insect-repellent treated polyethylene bag

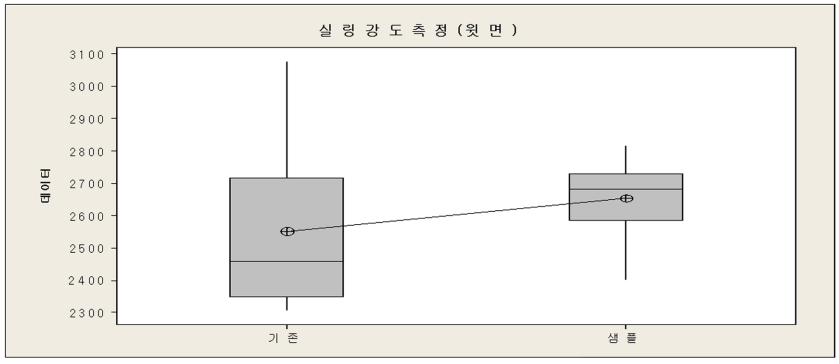
Test Items	Unit	Test Methods	Test Results
Residual Pb	mg/kg	(1)	Not detected
Residual Cd	mg/kg	(1)	Not detected
Residual Hg	mg/kg	(1)	Not detected
Residual Cr^{+6}	mg/kg	(1)	Not detected

Table 4. Elution test result (Material: Polyethylene)

Test Items	Unit	Test Methods	Test Results
Elution Pb	mg/L	(1)	Not detected
Elution potassium permanganate consumption	mg/L	(1)	1
Elution Total elution amount 4% acetic acid	mg/L	(1)	4
Elution total elution water	mg/L	(1)	1
Elution Total elution n-heptane	mg/L	(1)	14
Elution 1-hexene 4% acetic acid	mg/L	(1)	Not detected
Elution 1-hexene water	mg/L	(1)	Not detected
Elution 1-hexene n-heptane	mg/L	(1)	Not detected
Elution 1-octene 4% acetic acid	mg/L	(1)	Not detected
Elution 1-octene water	mg/L	(1)	Not detected
Elution 1-octene n-heptane	mg/L	(1)	Not detected

Table 5. Sealing strength measurement result after product packaging of insect-repellent film

Bag Sample	STM 5670 Sample, Width 1x6inch, Gauge 2inch, Speed 12inch/min							
	No insect repellent treatment				Insect repellent treatment			
	Top(N/m^2)	Bottom(N/m^2)	Elongation (%)		Top(N/m^2)	Bottom(N/m^2)	Elongation (%)	
1	2488.5	2563.3	30.4	55.7	2815.8	2623.8	101.0	297.4
2	2308.2	2563.4	15.7	23.6	2403.9	2417.0	113.6	234.6
3	2429.6	2378.1	27.5	34.6	2646.5	2414.1	111.6	260.6
4	2325.1	2544.3	24.1	29.8	2733.4	2642.6	68.1	293.9
5	2356.9	3103.5	14.3	41.9	2717.8	1946.8	49.4	209.1
6	3075.8	2256.7	43.4	29.6	2592.2	3108.9	85.5	341.3
7	2989.0	2703.6	51.9	37.9	2563.7	2153.5	83.1	271.5
8	2405.7	2369.3	55.5	55.9	2622.7	2107.2	111.7	246.7
9	2624.5	2709.4	41.2	29.6	2724.3	2613.9	132.4	283.9
10	2513.1	2432.3	47.6	37.3	2727.4	2548.0	88.6	268.9
AVG.	2551.6	2562.4	35.2	37.6	2654.8	2457.6	94.5	270.8
STD.	271.11	239.51	14.80	10.93	116.64	333.06	24.51	36.80

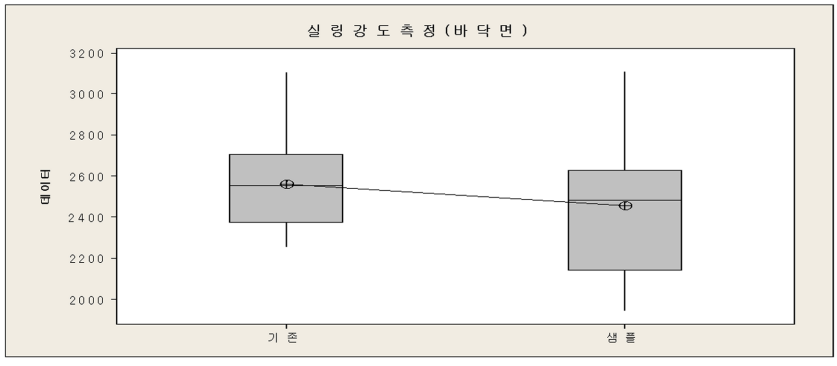


기존 대 샘플의 두 표본 T

	N	평균	표준 편차	SE 평균
기존	10	2552	271	86
샘플	10	2655	117	37

차분 = mu (기존) - mu (샘플)
차분 추정치: -103.130
차분의 95% CI: (-306.479, 100.219)
차이 = 0 의 T 검정 (대 not =): T-값 = -1.11 P-값 = 0.291 DF = 12

Fig. 1. Sealing strength measurement result after product packaging (top of bag).



기존 대 샘플의 두 표본 T

	N	평균	표준 편차	SE 평균
기존	10	2562	240	76
샘플	10	2458	333	105

차분 = mu (기존) - mu (샘플)
차분 추정치: 104.810
차분의 95% CI: (-170.202, 379.822)
차이 = 0 의 T 검정 (대 not =): T-값 = 0.81 P-값 = 0.431 DF = 16

Fig. 2. Sealing strength measurement result after product packaging (Bag bottom)

Table 6. Price comparison between existing film and insect-repellent film

PE Bag	Price (Won/EA)	Rate (%)	Total Cost (PE Bag + Product, Won/EA)	Rate (%)
Current	50.55	+7.0% Up	1534	+0.39% Up
New Grade	54.1		1540	

that there are no quality issues.

Lastly, as a result of receiving the final PE bag estimate for the application of film printing containing pest repellents, the packaging cost was expected to increase by 7.0% on average from 50.55 won to 54.1 won. However, in terms of total cost including product raw material costs, the upside factor was confirmed to be at a modest 0.39%.

Conclusion

The present study was conducted to accomplish management efficiency by preparing preemptive measures for consumer dissatisfaction and overcome risks caused by climate changes through studies of model cases in packaging. In short, it is a study on the case where manufacturer A achieved positive outcome by using all natural repellent instead of insecticide on the packaging for hygiene products. They did not use the method of changing the property of matter by adding mothproofer to the material of the film but rather added components of all-natural mothproofer in the printing ink to enhance the effects of the repellent through printing. The purpose of this experiment was to measure how much the *Plodia interpunctella* H. larva can punch a hole through the repellent film produced through printing with the ink containing ingredients of all-natural repellent to get inside the packaging and the controlled experiment was conducted using untreated LDPE film that does not contain any mothproofer. In the case of the packing company A, as a result of investigating the attraction control effects of repellent compounds by investigating the number of pupa and larva discovered in products, the exterior of the packaging showed results of $df = 30$, $t = 5.73$, $P < 0.0001$ while the cracks in the exterior of the packaging showed results of $df = 30$, $t = 2.66$, $P = 0.0124$.

Moreover, in the overall exterior of the packaging, the population discovered in $df = 30$, $t = 4.15$, $P = 0.0003$ was analyzed to have statistically significant differences in the significance level of 99% between products processed with mothproofer and products without. The population discovered in the exterior of the products were $df = 30$, $t = -8.51$, $P < 0.0001$ for the products processed with the mothproofer and $df = 30$, $t = -4.20$, $P = 0.0002$ for products without for there to be significantly more observed in crevices of both packaging where there were no printings. Meanwhile, the invasion into the product's interior due to punching was only discovered in the products with non-treated film but the population did not appear to be statistically significant($df = 30$, $t = 1.00$, $P = 0.3253$). In the film punching test of *Plodia interpunctella* H., it was found that the mouthparts of the *Plodia interpunctella* H. larva did not catch the unfolded side of the film and therefore, punchings were not observed when the film was unfolded. However, the larva effectively triturated the folded film side and most of the punching could be observed when the film was folded. When the film is folded, the punching rate for packing companies A and B for existing film was 94.4%(17) and 83.3%(15) whereas the films processed with repellent showed punching rates of 38.9%(7) and 27.8%(5) for companies A and B respectively. The numbers decreased from 94.4%(17) to 38.9%(7) and 83.3% (15) to 27.8%(5) when the film was processed with repellent to show experimental results verifying effects of repellent by decrease in 55.5%(10).

Such results show that it is safe when the film is unfolded, but in the case where the film is folded, the *Plodia interpunctella* H. punches through the film to lead to consumer dissatisfaction and it suggests that this can bring on risks to corporate management. Considering that most of the film is folded in the case of PE bag packaging, the direction which the corporations should take in terms of preparing for climate change countermeasures and consumer dissatisfaction has been clarified. It has confirmed that the repelling effects of harmful insects can certainly change through the comparative analysis of this experiment on products processed with repellent printing material and products with regular packaging when the film is folded. There is significance in this study due to it being found that this process does not influence the production and packaging process since the material of film is not being changed but it is effective as the ink containing repellent is used for printing. Due to it receiving satisfactory results in safety rest results for printing film applied with pest repellent as well as the Quality analysis to test repellent contents of repellent film, it is certain that the importance of repellent method in packaging will increase in preparing for consumer dissatisfaction and actions against climate change henceforth. .

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