Effect of Oxygen Absorbers on Storage Quality of Sliced Ham

SUMMARY[1] OF EXPERIMENTATION AND RESULTS OF STUDIES CONDUCTED

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ABSTRACT

The effect of commercial oxygen absorbers on sliced ham quality packaged in barrier film (OTR @ 60cc/m^2/da) under rigorous display conditions was investigated. Atmospheric pressure, vacuum, and CO_2 back-flushed packaging methods were used. Color, microbial counts, lipid oxidation, and sensory odor were evaluated weekly over a period of 79 days in 10°C storage under fluorescent light.

Ham containing oxygen absorbers had lower psychrotrophic bacteria, yeast and mold counts, and better color retention (Hunter L value) compared to packages without absorbers. Lipid oxidation and sensory odor were not different among treatments with the very low (<2%) fat ham product used for the study.

Shelf life is improved to the greatest extent when the appropriate oxygen absorber is used in CO_2 gas-flushed packages in barrier film.

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INTRODUCTION

Cured meat color is a result of the compound nitrosylhemochrome, which is formed during the curing process. This compound is sensitive to oxidation, which is catalyzed by light, resulting in the development of undesirable brown color (Kinsman et al, 1994). Oxygen also contributes to lipid degradation in meat resulting in oxidized or rancid odor. The presence of oxygen also promotes the growth of aerobic organisms such as molds, which are the major spoilage organisms in low water-activity food. Cured meat products are either vacuum packaged or back-flushed with carbon dioxide or nitrogen to inhibit deterioration. Oxygen barrier films are used to limit ingress of oxygen via permeation. Oxygen absorbers react directly with residual oxygen when placed in the package.

Oxygen barrier films used in combination with absorbers can retard deterioration of cured meats. It is a purpose of this study to confirm and quantify these effects in a practical MAP packaging format.

Oxygen absorbers combined with high barrier films have been successfully shown to inhibit mold spoilage in cheese and baked products (Alarcon and Hotchkiss, 1993; Smith et al, 1986), prevent oxidation of polyunsaturated fatty acids in fish (Suzuki et al, 1985), and eliminate discoloration of ham (Andersen et al, 1992). Alarcon and Hotchkiss (1993) used films with oxygen transmission rate ranging from too low to measure to 32 cc/m^2/24hrs with vacuum packaging to obtain satisfactory results. In both levels of barrier film, the addition of oxygen absorbers showed significant inhibition of mold growth in bread and prevention of off-flavor development in sunflower seeds and corn chips. Andersen (1992) showed that oxygen absorbers combined with barrier film of 2 cc/m^2/24 hrs/atm eliminated discoloration of pasteurized sliced ham displayed on an illuminated shelf. Use of the oxygen absorber resulted in higher quality than conventional vacuum packaging. Smith (1986) used plastic film of 40 cc@73 °F 1atm/m^2/24 hrs OTR to monitor the control of oxygen concentration and mold growth in packaged bakery products. The study showed that the absorber reduced the headspace oxygen to less than 0.05% within 9 hours and prevented mold growth in bakery product for more than 60 days.

The barriers were high in all three studies: OTR too low too measure, 2cc, 32cc, and 40 cc/m^2/24 hrs/atm. The higher the barrier properties of the packaging, the greater the cost to the meat processor. Gas flushing, another way to reduce headspace oxygen, is, likewise, an added expense. While satisfactory shelf life can be obtained by these methods, it would be desirable in many cases to increase shelf life and/or avoid the costs of the highest available barrier film by using a commonly available moderately high barrier film.

Our primary objective was to determine the effect of oxygen absorbers on the color, oxidation, microbiology and odor of cured ham packaged in several different ways under extended and difficult display conditions of light and temperature.

MATERIALS & METHODS

Product:

Commercial Danish cooked ham (supplied by Marks & Spencer, Ltd. through Majesty Inc., Cranford, NJ - 1.8% fat, 17.9% protein) was used. The ham was stored at 4°C before slicing and packaging. Five slices, ~3mm total thichness, of ham were randomly packed into 15 x 25 mm pouches.

Package Materials:

A moderately high barrier package film was used, P640, nylon/saran with OTR of 60 cc@73°F/1atm/m^2/24 hrs (Cryovac, Duncan, SC). Pressure sensitive adhesive, label type oxygen absorber packs were manually attached inside the plastic pouch, partially in contact with the product before sealing. Three types of oxygen absorbers, all 10 cc O_2 absorbtion capacity, were used: FreshMax® Type B (Multisorb Technologies Inc., Buffalo, NY) for vacuum packaging, FreshMax® Type M (Multisorb Technologies Inc., Buffalo, NY) for CO_2 modified atmosphere packaging (type 1, a new smaller format heat sealed version and type 2, a standard version).

Packaging Conditions

Five packaging procedures are outlined in Table 1.

Test Conditions

After packaging, all pouches were placed in a dark storage room for 12 hours to allow oxygen absorber to take effect. All packages were stored in a walk-in cooler at 10°C with air circulation, 85% relative humidity, and under continuous light. Light sources in the storage room were fluorescent tubes (General Electric, F96T12)measured at 1076 lux at the surface of the product.

Table 1: Packaging treatments of sliced ham.

Code	Vacuum	CO_2 flushed*	Oxygen Absorber
Vc	Yes – 0.9 bar	No	No
Vc Abs	Yes – 0.9 bar	No	FreshMax Type B-10
CO_2	Yes – 0.6 bar	Yes	No
CO_2 Abs 1	Yes – 0.6 bar	Yes	FreshMax HS, M-10
CO_2 Abs 2	Yes – 0.6 bar	Yes	FreshMax std., M-10

***** 78% CO_2, 2.4% O_2, bal. N_2

ANALYSES

All analyses were done in duplicates at day 0, 9, 16, 23, 30, 37, 51, 65, and 79, using new packages for every data point.

Headspace Gas Composition

Headspace composition was analyzed for O_2 and CO_2 concentration by gas chromatography with thermal conductivity detector (Varian Aerograph series 2700, Walnut Creek, CA), using Molecular sieve column for O_2 and Chromosorb column for (CO_2). Helium was used as a carrier gas at flow rate of 7.7 ml/min. The column temperature was 65°C. The injector temperature for O_2 and CO_2 were 100°C and 120°C, respectively. The detector temperature was set constant at 150°C. Airtight self adhesive rubber septum was applied on each package. Air sample was taken using a 0.25ml gas-tight pressure-lock syringe (Precision Sampling Corp., Baton Rouge, LA). Peak heights were analyzed using chart recorder with sensitivity of 0.5%.

Microbiological Evaluation

Total aerobic, anaerobic, psychrotrophic, and yeast and mold count were determined using the plate count method. Packages were aseptically opened and 9 grams of sample were mixed with 99 ml of sterile phosphate buffer in a stomacher bag. The content was stomached for 2 minutes in Seward Stomacher 400 (Tekmar, Cincinnati, OH). Dilutions were made from 10^{-2} to 10^{-6}. Total aerobic, anaerobic, and psychrotrophic counts were plated using standard method PCA agar and incubated at 35°C for 48 hours, anaerobically at 35°C for 5 days, and at 7°C for 10 days, respectively. Yeast and mold counts were plated with antibiotic agar and incubate at 25°C for 5 days. Results were reported as colony forming units per gram of food (CFU/g).

Moisture

Moisture content of the ham was determined using oven drying method (AOAC method 950.46). Ten grams of sample were ground in a blender and 2 grams of ground sample were placed into predrilled aluminum pans. The samples were dried in vacuum oven (20 inches Hg in vacuum) at 100°C for 5 hours.

pH

Five grams of sample were blended with 50 ml of distilled water. The slurry was filtered with #1 Whitman filter paper. The filtrate pH was measured using pH meter (Fisher Acumen model 610, Pittsburgh, PA).

Color measurement

The top slice of ham in the package was wrapped with clear plastic wrap and the hunter color values (L, a, and b) were measured by averaging four quadrants of the slice, using Macbeth Coloreye colorimeter(Kollmorgan instruments Corp., Newburgh, NY).

Odor evaluation

Sensory odor were evaluated by a thirteen-member trained panel, using a 1 to 15 scale, representing no off odor to strong off odor. Five grams of sample were put in a screw capped brown bottle and labeled with 3-digit number. Fresh sample and extreme odor standards were presented as a reference for the panelists at every session.

TBA value

TBA (thiobarbituric acid) value was determined using the distillation method for cured product as describe by Koniecko (1979) .Ten grams of sample were blended with 49 ml deionized water and sulfanilamide reagent (1 g in 200 mL 40% HCl). The content and additional 48 ml of water was poured into a round bottom flask. The pH was adjusted to 1.5 using 2 ml of HCl, and antifoam and glass beads were added to the flask. The content was heat on high until boiling. The 50 mL distillate was collected in 15 minutes. Five ml of distillate were mixed with TBA reagent (0.288 g in 90% acetic acid) and then heated in a boiling water bath for 35 min. The color development was measured at 538nm using a spectrophotometer. TEP (1,1,3,3-tetraethoxypropane) standard was made. Results were reported as mg of malonaldehyde/ 1000 grams of sample.

Statistical analysis

All experimental results were analyzed using analysis of variance and Fisher's multiple comparison procedure on MINITAB computer program.

RESULTS AND DISCUSSION

All package variables were analyzed until the end of the experiment, day 79.

The headspace oxygen inside the packages at day 1 differed significantly ($p<0.05$) between treatments. The packages with the absorbers had a lower concentration of headspace oxygen than the packages without the absorbers. The differences were greater in vacuum treatment than in the gas-flushed treatment due to the higher initial concentration of oxygen. After day 9 to the end of the experiment, the oxygen concentration in the packages was similar in all treatments, about 2%. This can be explained by the use of oxygen by microorganisms or the reaction of the absorber, depending on the treatments. The 0% oxygen concentration, expected in the absorber treatments (Anonymous, 1989), was not observed in this experiment; perhaps due to insufficient head space (<50 cc) which prevented the absorber from picking up O_2 which permeated the film.

The time intervals between the first two measurements, 8 days, and the low oxygen barrier films allow some ingress of oxygen contributing to high oxygen concentration. The sensitivity of GC, 0.5%, may also be accounted for the high reading. Lastly, the product was either vacuum-packed or gas flushed in slight vacuum and sliced ham did absorb part of the headspace gas. The retardation of psychrotrophs and yeast and mold, along with color retention, the expected effects of near-zero oxygen concentration, were observed; as discussed below.

Figures 1 and 2 show the effect of oxygen absorber on the growth of aerobic microorganisms. The absorber had no effect on aerobic organisms in vacuum and gas-flushed treatments. Aerobic counts did not rise rapidly nor reached a very high level until late in the study; a pattern expected with facultative organisms. Andersen (1992) also found no significant difference in aerobic microbial counts in vacuum packages with or without absorbers. Gas flushed treatments at 10°C storage had no advantage in microbial count over vacuum packaging (Boerema, 1993).

The results of psychrotrophic counts of sliced ham in different types of packages are shown in figure 3 and 4. The oxygen absorber showed a significantly lower ($p<0.05$) psychrotrophic count at day 9 in gas-flushed treatments. The difference became insignificant from day 16 on. However, in most cases, packages with absorbers in high barrier gas flushed packages had lower psychrotrophic counts than those without absorbers.

Figure 5 and 6 show the yeast and mold plate counts results of sliced ham. Oxygen absorbers significantly retarded the growth of yeast and mold in gas flushed packages. The differences in yeast and mold count were significant ($p<0.05$) at day 9, 16, 23, 37, 51 and 65 between CO_2 flushed packages with and without absorbers. Differences due to absorbers were not significant in all other non gas-flushed treatments. Gas flushed packages generally had lower yeast and mold count than vacuum packages. Elevated CO_2 concentration may have an inhibitory effect mold growth if the O_2 concentration is sufficiently low (Smith, 1986). Since no packages developed visible mold during the experiment, it could be suggested that the O_2 concentration might have reached the critical limit and remained at the point through out the entire experiment.

Hunter L values, the measure of lightness-darkness (white versus black), of sliced ham were shown in figures 7 and 8. The L values in ham in vacuum packages without the absorber increased during storage indicating an increased whiteness and a loss of color. Visibly, the ham became less pink and lighter gray in color. Those with absorber maintained pinkness and increased less in L value. Throughout the experiment, samples with an oxygen absorber exhibited lower L values indicating a product less gray and visibly more pink. Significant differences ($p<0.05$) between vacuum packed samples were found at day 30 and 79. The same effects were also observed in the gas-flushed treatment. Absorbers had a significant effect in CO_2 flushed high barrier packages at day 30, 37, and 79.

The effect of oxygen absorber on sensory odor evaluation was insignificant ($p<0.05$) in all treatments. However, some differences were observed. The oxygen absorber had an effect on some treatments , but the difference was not large enough to be statistically significant.

Other quality assessments such as anaerobic plate count, moisture content, pH, Hunter a value, b value, and TBA value were not significantly different for any treatment.

Anaerobic plate counts were not increased with the use of absorbers. Anaerobic counts in the first 23 days were undetectable to very low. Large increases occurred after day 23 to 10^4 CFU/g at day 30 and to 10^7 CFU/g after day 51. This is due to depletion of oxygen early in the storage life and adaptation of facultative organisms.

Moisture content remained stable at 74% throughout the experiment. Initial variability was due to differences in moisture content between individual slices, which equilibrated within the packages after the first day. The pH of ham was initially 6.30 and fell to $\geq$6.00 at the termination of the experiment.

Hunter a value, the measure of redness, dropped significantly after day 1. Since Hunter a value is found to have the best correlation with visual determination (Andersen, 1988), significant lost of a values would effect acceptability. Samples with an oxygen absorber had higher *a* values later in the study. Hunter *b* value, the measure of greenness, did not show any change during the experiment in all treatments. The higher *a* values associated with the absorbers were readily observable with the naked eye.

TBA values, which measure lipid oxidation remained low through out the entire experiment with slight increase toward the end. The unusually low fat content of the product may be associated with the low TBA value.

CONCLUSIONS

In moderately high barrier films, oxygen absorbers retarded the growth of psychrotrophic bacteria, yeasts, and molds and preserved color as measured by L values of sliced ham, especially in CO_2 flushed high barrier packages.

In most cases, oxygen absorbers slowed the growth of psychrotrophic organisms and preserved L value in vacuum packages as well. Oxygen absorber did not prevent the lost of redness in the low oxygen barrier film but did retard the development of grayness which resulted in product with far more visual appeal particularly in the middle and late stages of the experiment.

There was no significant change in moisture content, pH, and TBA value of sliced ham when packaged with the oxygen absorber.

There was no discoloration of the product due to direct contact with the absorber. However, the surface of the FreshMax, standard type, 2”x2”, sachet did show some discoloration itself at day 9. The smaller format heat sealed version showed no discoloration during the life of the experiment.

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Figure 1. Aerobic plate count of sliced ham in vacuum packages stored at 10°C

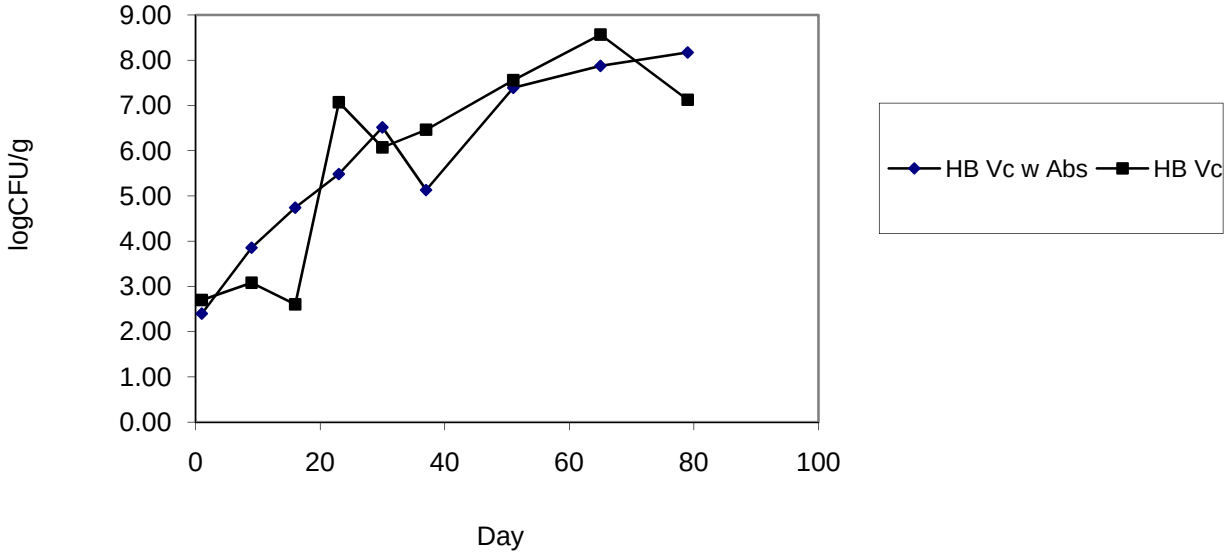

Figure 2. Aerobic plate count of sliced ham in gas flushed packages stored at 10°C

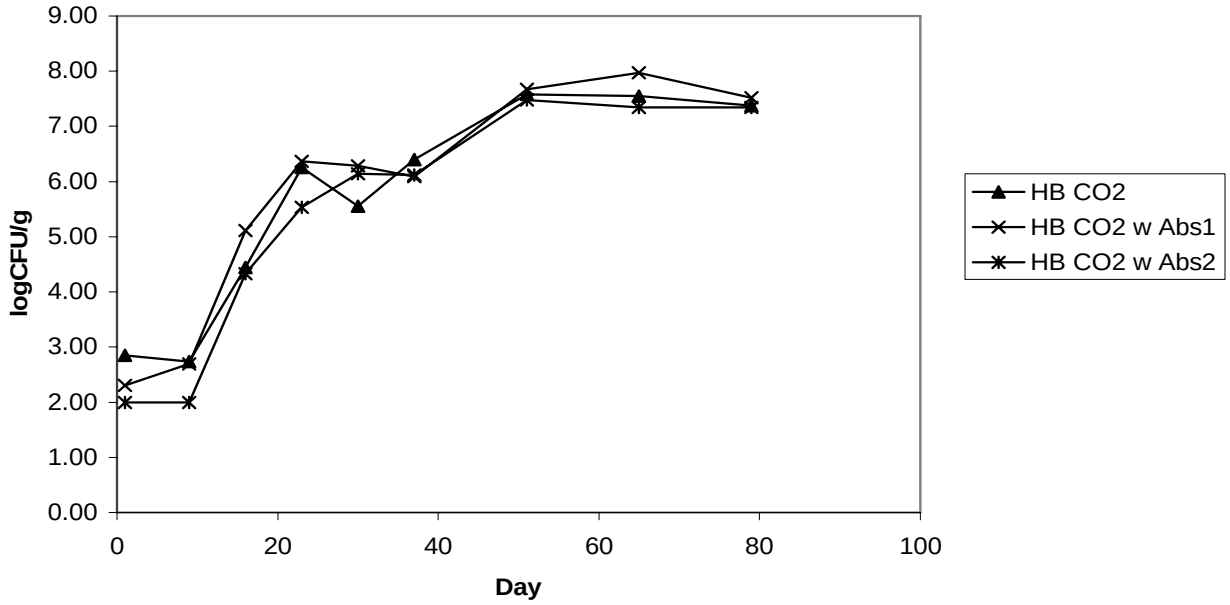

Figure 3. Psychrotrophic count of sliced ham in vacuum packages stored at 10 oC

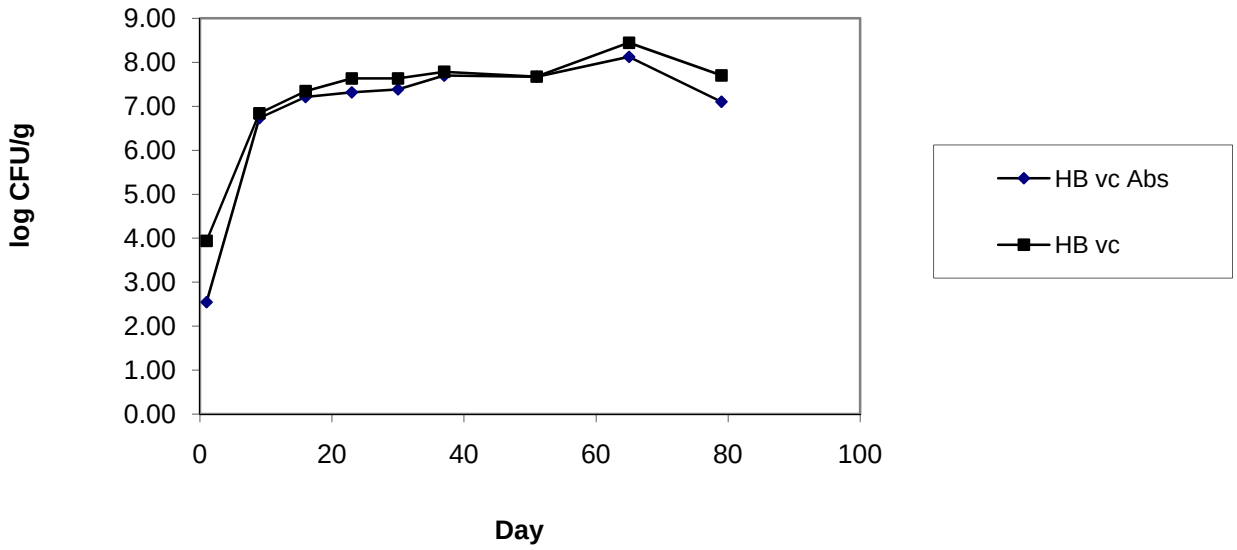

Figure 4. Psychrotrophic count of sliced ham in HB gas flushed packages stored at 10oC

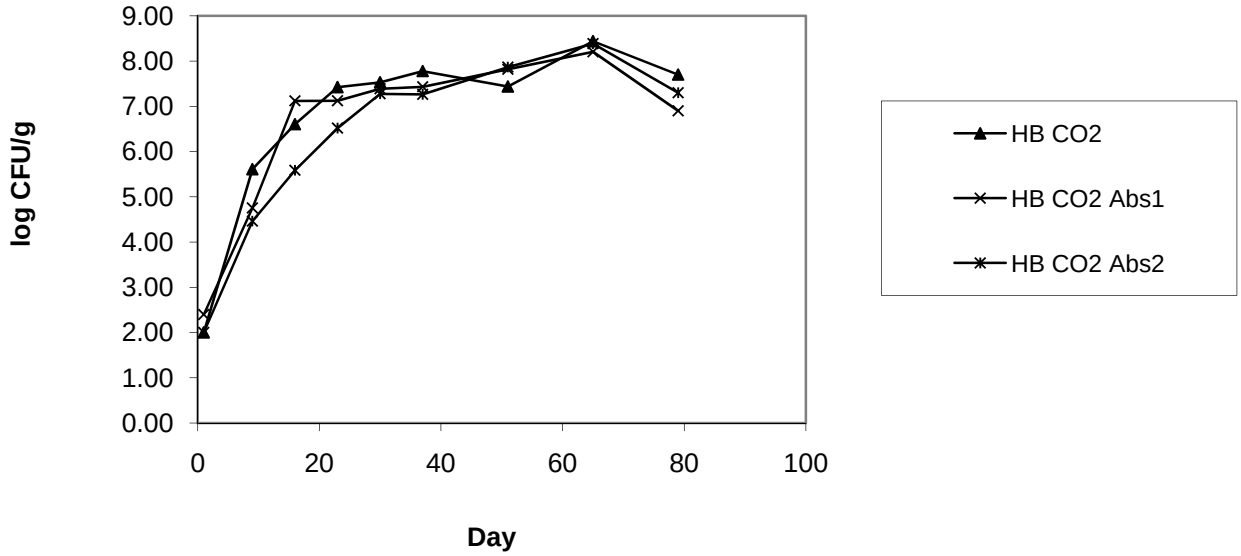

Figure 5. Yeast and mold count of sliced ham in vacuum packages stored at 10 oC

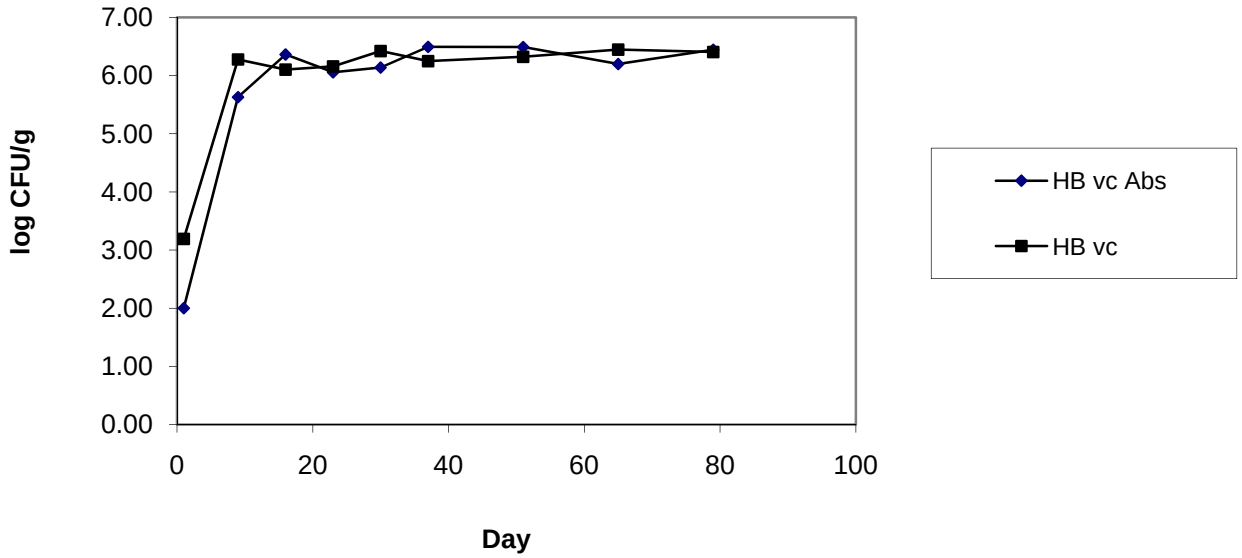

Figure 6. Yeast and mold count of sliced ham in gas flushed packages stored at 10 oC

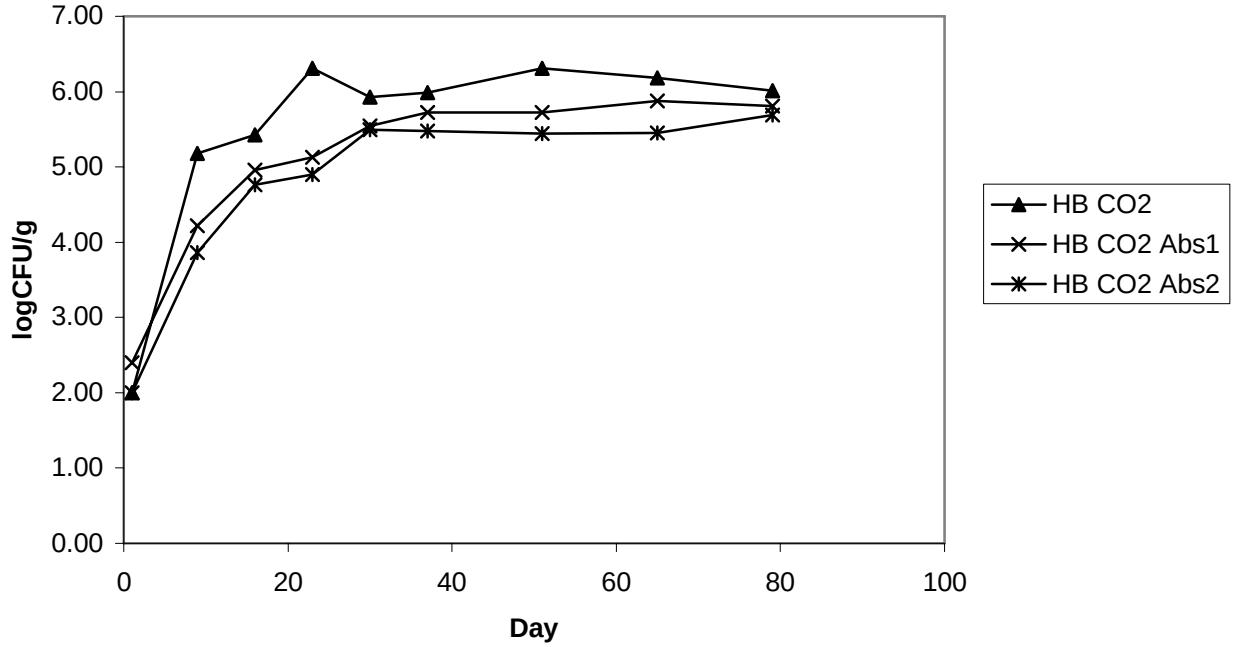

Figure 7. Hunter L value of sliced ham in vacuum packages stored at 10 oC

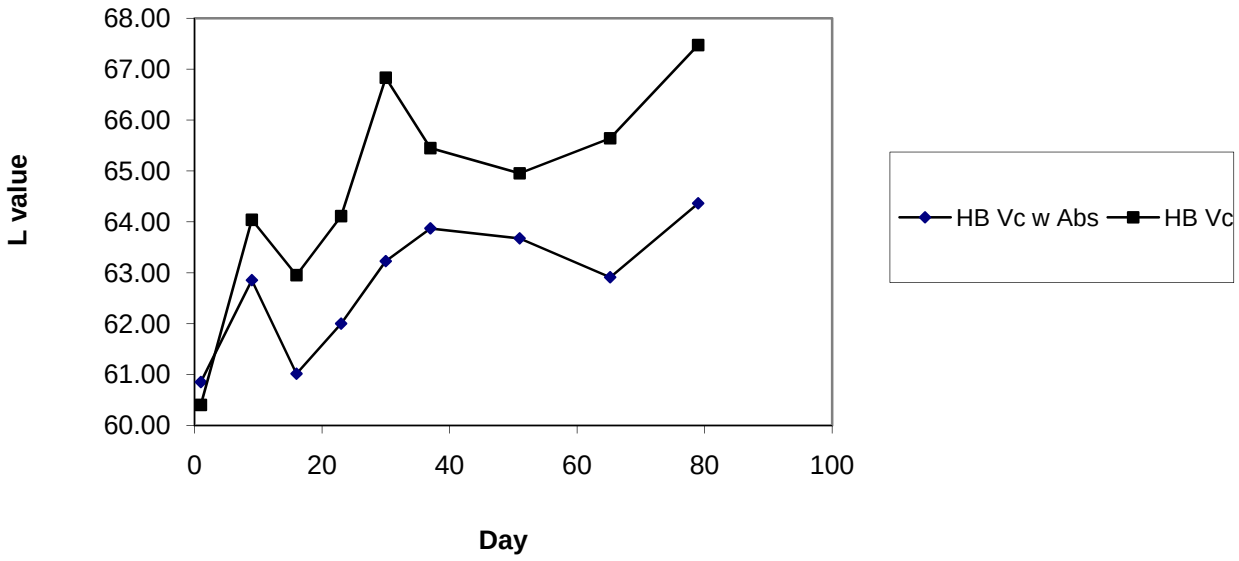

Figure 8. Psychrotrophic count of sliced ham in Lb vacuum packages stored at 10°C