An Evaluation of the Plastic Coated Pure-Pak Carton for the Packaging of Extended Shelf-Life Milk

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AN EVALUATION OF THE PLASTIC COATED PURE-PAK CARTON FOR THE PACKAGING OF EXTENDED SHELF-LIFE MILK

By

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AN ABSTRACT

Submitted to the College of Agriculture of Michigan State University of Agriculture and Applied Science in the partial fulfillment of the requirements for the degree of

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ABSTRACT

The need for a longer shelf-life of pasteurized dairy products has been brought about by the centralizing of milk processing operations and the resulting commitment to longer distribution systems with less frequent deliveries.

The adequacy of the existing plastic coated Pure-Pak carton in such a system and modifications of the basic carton structure were investigated. Modifications included (a) the addition of a .00035 aluminum foil lamination, (b) skiving of the interior raw edge of the carton, and (c) sterilization of the carton with ethylene oxide gas.

The ability of the basic carton with or without modification to protect and contain the product were determined by (a) an evaluation of product flavor during extended storage, (b) measurements of carton bulge during a "free standing" period subsequent to casing using two case styles, (c) the effect of extended transport on bulge, and (d) the bacteriological condition of carton blanks prior to use in the dairy.

No relationship was found between carton type and the flavor deterioration of whole milk. Pasteurized milk had a higher score at four weeks' storage than sterilized milk.

The length of time cartons were held in a "free standing" condition was a very significant variable.

In the bulge tests, none of the values obtained exceeded the generally accepted limits of 14/32 inches over the square dimension of the carton. Even so, the length of time in a "free standing" situation was a

very significant variable. The difference in bulge between cartons held loosely in metal case and tightly in a corrugated case was real. Bulging with time followed parallel courses for each carton regardless of type of casing.

Cartons subjected to vibration and handling during a 500 mile test showed a slightly higher bulge.

Bacteriological examination by a swab test of 1050 carton samples showed 28 with counts of from one to six per carton, assuming 52 square centimeters per test.

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INTRODUCTION

The keeping quality or "shelf-life" of packaged milk products has always been of prime interest to dairy processors. This "shelf-life" is a limiting factor and its influence is felt at all levels of processing and distribution. If milk products could be processed and packaged so as to extend the useable life of the product, efficiencies in the areas of production and distribution could be realized. Also, the consumer would be assured of a more consistent, high quality product.

Milk becomes unsaleable due to changes caused by microbiological or physical factors. A processing and packaging system must be devised to control these factors. Two approaches are being suggested to attain this extended "shelf-life". The sterile approach requires the use of ultra high temperature processing, product handling and packaging under sterile conditions in a sterile package with or without refrigerated storage. The "ultra-clean" approach involves the use of existing processing techniques, improved handling and sanitation methods with attention given to the reduction of contamination in the packaging area, an ultra clean system which would reduce bacterial contamination following pasteurization. The product would be held and distributed in a refrigerated system.

The Ex-Cell-0 Corporation has developed an aseptic packaging system for milk products. It involves the use of a specially designed

machine which maintains a sterile atmosphere in the carton filling and sealing area. The products so packaged would be subjected to higher than normal processing temperatures to ensure complete destruction of bacteria. In milk products, this higher heat treatment gives a characteristic "cooked" or heated flavor which is different from normally pasteurized milk. Customer reaction to this flavor could be adverse. Ex-Cell-0 has determined that for sterilized products a sterile plastic coated Pure-Pak carton with a foil lamination is needed. This carton, sterilized with ethylene oxide gas would not contribute to the contamination of the product. The foil lamination provides the additional light and gas barrier properties needed for a long storage life (60 days). Storage of the product could be in either a refrigerated or unrefrigerated condition.

The cost of the sterilized foil laminated carton is significantly higher than that of the regular plastic coated carton. The price per thousand for a two-color foil laminated carton is $35.00. The price for a two-color regular plastic coated carton is $15.58.

The Ex-Cell-0 Corporation's Aseptic Machine could be used as a component in the "ultra-clean" approach.

This study was initiated to determine the adequacy of the existing plastic coated Pure-Pak milk container as a package for the ultra-clean approach, and to determine if modifications were necessary to improve the product protection, strength, or bacteriological qualities of the

carton as a component in an ultra-clean processing and packaging system.

LITERATURE REVIEW

Olsen, et al. (27) noted at least three trends which accent the importance of factors influencing shelf-life; the lengthening of time between processing and distribution, more milk being processed and distributed by centralized plants and distribution over a wider area.

Hedrick and Hall (13) stated that high retail delivery costs (approximately one-third of the customer price), besides those of refrigeration, handling, storage, and distribution have stimulated the development of aseptic packaging of milk and cream.

Elliker (8) observed that results have further demonstrated that the improved keeping quality attained pays dividends in a longer marketing period, fewer returns, and fewer customer complaints.

Overcast (29) wrote that in his opinion today, the most important bacterial problem the industry faces is that of psychrophilic organisms. He stated that we are dealing with these organisms that grow in milk or its products at refrigeration temperature at such a rate as to bring about objectionable changes before its consumption. Given a generation time of six hours at 45° F. and only one of these in a quart of milk, the count increases to one million per ml. after eight days of storage.

By and large, these organisms are of soil and water origin; they are destroyed by pasteurization but find their way into the milk through improperly sanitized or contaminated equipment.

Psychrophilic organisms are able to grow below 5° C. and do not survive heating at 145° F. for 30 minutes. Their presence in appreciable numbers in pasteurized products is evidence of post-pasteurization contamination. Pseudomonas, Achrobacter, Flavobacterium, and Alcaligines are psychrophilics according to Thomas (37). A low temperature hold slows down but does not stop psychrophilic growth.

Olsen, et al. (27) noted the major factor of keeping quality is metabolic activity of bacterial species which are capable of relatively rapid growth in milk at low temperature, generally in the range of 35-45° F. Taking into consideration lag time and generation time, Harper (11) calculated the expected shelf-life of fluid milk with a contamination level of one per package, based on the observation that over one million psychrophilic organisms per ml. results in unsalesable fluid milk products. A one-half pint of milk held at 45° F. would have a shelf-life of 16.5 days; a quart, 17.5 days.

Randolph, et al. (31) in a study of the keeping quality of market milk stated that the results of the bacteriological examinations reveal considerable variations in the sanitation programs of the different plants and provide explanations for the differences observed in the keeping quality. The fact that a majority of the samples contained organisms capable of growing at 40 to 45° F., which is indicative of the presence of psychrophilic organisms resulting from post-pasteurization, suggests

that considerably more care is needed to avoid contaminating of the pasteurized product.

Irvin (20) stated that during the past few years, there has been a growing interest in the pasteurization of milk and milk products at higher temperatures. The principal economics of higher heat processes are an improvement in shelf-life. This in turn permits handling and distribution practices that result in such important changes in plant operations as concentration of plant facilities, less frequent deliveries, and extension of sales areas.

Jordan (22) stated that the most significant change in dairy products subjected to ultra-high temperature (UHT) treatment is the reduction of the viable microorganisms to essentially zero. The extent of destruction of microorganisms necessary to produce a sterilized product determines the intensity of the heat treatment required, which in turn determines the extent of other changes that take place in the products.

Pasteurization is defined by the Grade A Pasteurized Milk Ordinance (3) as the process of heating every particle of milk or milk product to at least 145° F. and holding it continuously at or above this temperature for at least 30 minutes, or to at least 161° F., and holding it continuously at or above this temperature for at least 15 seconds in equipment which is properly operated and approved by the health authority.

Read, et al. (32) in commenting on pasteurization stated that from a public health standpoint, pasteurization has a single function; to inactivate any viable pathogenic microorganism present in the raw product so that these microorganisms cannot impair the health of the consumer. The Public Health Service has received several requests for milk and milk product pasteurization standards for processes that would involve shorter holding times and higher holding temperatures than are now being used for high-temperature short-time (HTST) pasteurization. These processes are given the general label of ultra-high temperature (UHT) pasteurization. For purposes of identification, UHT pasteurization for milk and milk products can be defined as a group of thermal processes for dairy products that have holding times of 2 seconds or less with holding temperatures of from 190 to 270° F. The upper limit of 270° F. was selected because most heating processes for milk and milk products that use holding temperatures above 270° F. are designed to sterilize rather than pasteurize.

Holland (18) indicated that the production of sterilized milk of a satisfactory table and beverage quality has occupied the attention of numerous dairy research workers over many years. The advantages of such a product are obvious. The fact is, however, that no one has yet produced a product that matches the flavor of the high quality pasteurized milk that is available to the American housewife. Flavor is the most important attribute of milk products.

Holland (19) observes that many processors no longer hold closely to the pasteurization standards in their heat treatment procedure but are using higher temperatures for longer times. In the case of sterile products, temperatures may approach or even exceed 300° F. with holding times reduced to a few seconds. In view of these facts it may be timely to take a look at some of the effects of increased heat treatment on the constituents of our product.

Johnson (21), Irvin (20) and Herried (17), have all commented on the effects of UHT heat treatment of milk. The cooked or heated flavor is inevitable created in all products during sterilization. The shelf-life of sterile fluid milk products is limited by cream rising, fat oxidation, settling of solids, chalkiness, gelatin and off-flavors.

Gould (19) comments that due to the intricacy of the normal milk system, the heating of milk may be expected to create many new relationships and inter-relationships among the constituents and to form a multitude of compounds not present originally. These chemical compounds in turn are responsible for certain changes which are obvious to the consumer; changes such as flavor and color which definitely affect the marketability of the final product.

The temperature at which the processed product is held is a factor. O'Sullivan and Keogh (28) observed that the two critical factors limiting the shelf-life of UHT cream are chemical off-flavor development and physical separation. The shelf-life can be markedly extended by low temperature storage of the product. Herried (17) notes that at present there is no substitute for low temperature storage for maintaining

and prolonging the palatable shelf-life of sterile fluid milk products.

While aseptic packaging has been receiving the publicity, the practical milk plant operators have recognized the need for more efficient pasteurization, improved sanitation and cleaning practices. Equipment manufacturers have modified and improved filling machines that can now handle and fill cartons in a nearly sterile atmosphere. Tests have proven that milk processed under these controlled conditions, given reasonable care in the distribution process will have an extra week or perhaps more of shelf-life, requiring less frequent deliveries to the store and enabling processors to expand marketing areas (1).

Lisiecki (24) stated that storage at low temperature slows the reactions causing unwanted changes in product characteristics and that to date, no substitute for low temperature storage to maintain palatability has been found. No sterilization process completely avoids the problem of cooked and off-flavors in the heated product.

Heldman, et al. (16) stated that the shelf-life of many food products, in particular milk and milk products, is directly related to the amount of bacterial contamination which occurs after processing. The importance of post-pasteurization has been emphasized by the increased interest in high-temperature processing and sterilization. Since a part of this contamination is due to contact of the product with airborne microorganisms, methods and equipment must be developed which will prevent airborne

contamination, especially during filling and packaging. Hedrick, et al. (14) took samples, using a Casella vacuum slit sampler, from three areas in a dairy operation. The average bacteria count of 315 samplings in the three areas was 27.0, the range was 0 to 155 for 5 cubic feet of air. More specialized air tests whereby a worker was confined to a small container were conducted. The air was sampled after it was drawn through a high efficiency filter and past the worker from head to foot. These data suggest that individuals are a prime contributor of bacteria to air within a building. Air sampling tests have confirmed that floor drains are a source of airborne contamination. A few trials have shown that supplies from dusty storage rooms can increase airborne contamination.

Heldman, et al. (15) noted that theoretically, it would be desirable to maintain the airborne population in food packaging areas at zero to prevent any degree of contamination. However, under operating conditions, it is impossible to avoid all contamination due to the presence of workers and the many other factors which contribute to the overall count. On the other hand, methods available for removing microorganisms from air provide a means of limiting the population at least in an isolated area in which the factors contributing to the count can be controlled.

The concept of laminar flow was developed to meet the needs for dust-free conditions during assembly of small components or precision instruments. The basic principles involved in a laminar air flow bench

or chamber are: (a) remove all particles 0.3 microns and larger from an air supply by using ultra-high efficiency filters, (b) direct this filtered air through a selected space at a low velocity (usually 50 to 200 ft/min), and (c) prevent mixing of filtered and unfiltered air within the selected space.

Laminar air flow clean rooms are described in Contamination Control Principles (2). A clean room needs: (a) A self-clean-down capability to combat both contamination brought into and generated within the room; (b) Air-flow patterns which carry airborn contamination away from the work and the work area; (c) Reduced personnel restrictions, and (d) Lower maintenance costs. This laminar flow technique can be adapted to rooms, tunnels, curtained units, hoods, and work stations.

Hedrick (12) stated that steady developments taking place in the sterilization and aseptic packaging of liquid milk products in recent years portend the opportunity for dynamic changes in the future. The magnitude of research on packages and aseptic packaging is reason for optimism. Aseptic packaging means the sterilization of the container, filling and sealing it without contamination of the product. Aseptic packaging systems are still limited primarily to Dole equipment for metal cans and Tetra Pak with cartons of paperboard, foil, and plastic films. Our MSU trial shows promise using a Pure-Pak type aseptic filler and carton losses during storage have been reduced to less than 1%.

Mann (26) noted that the first aseptic Tetra Pak was at the Coop Dairy in Berne, Switzerland. Milk, 15% cream, chocolate milk, and

chocolate and vanilla custard are packaged.

Mann (25) described the Tetra Pak system. The Tetra Pak Brix Aseptic Machine involves the sterilization of the packaging material in a hot hydrogen peroxide bath and the maintenance of sterility during the subsequent stages by means of pressurized sterile air. The strip of packaging material passes through the hydrogen peroxide at 176° F. and receives 8 - 9 second treatment. An air blast is employed to remove the chemical adhering to the packaging strip, which is then formed into a tube, filled with product and shaped into rectangular containers. The forming and filling sections of the machine are completely enclosed within a chamber in which an atmosphere of sterile air is maintained above atmospheric pressure.

In discussing the packaging needs for sterile milk, Hedrick and Hall (13) observed that the packaging material for sterilized milk had to be specially designed to stand up to handling and prolonged storage. Several combinations have been tried. One that appears satisfactory in preliminary trials consists of 90-lb. paper with a 1-mil coating of polyethylene, 1-mil aluminum foil, and an inside layer of 2-mil polyethylene.

Lisiecki (23) described the Aseptic Pure-Pak as a machine in which operations are carried out in a sterile environment. The Pure-Pak system is designed to prevent the invasion of organisms. The Pure-Pak blank is a five ply laminate. From the inside out, the layers are polyethylene, aluminum foil, polyethylene, paper, and polyethylene. Boxes of blanks are sterilized by the supplier with ethylene oxide gas

prior to shipment and remain sterile until opened. During processing, the carton is mechanically handled in a non-sterile environment for a few seconds. It must therefore undergo a minor resterilization treatment to eliminate any casual recontamination which may have occurred. On the Pure-Pak, this secondary treatment is a hydrogen peroxide fog, which in turn is dried with hot air at approximately 500° F.

Lisiecki (24) found that the standard Pure-Pak carton was not suitable for an aseptic system with a high temperature storage requirement. Yeast, molds, and bacteria caused contamination. A method of carton sterilization using ethylene oxide was tried and found to be very effective. He concluded that the foil-lined container, ethylene oxide treated is the container of choice for the time being. Tests did indicate an extremely low bacterial load on the surface of the carton itself. This was in the range of zero to five organisms per carton.

Prucha (30) commented on the development of the paper milk container. The bottling of fluid milk in paper containers is not a new idea. In a book by Kenneth Winslow, 1909, "The latest departure in the way of a milk bottle is the single service milk container of pulpwood invented and made by G. W. Maxwell, San Francisco, Calif." While the milk container was invented some thirty years ago, very little attention was paid to it by the fluid milk industry or by the milk sanitarians.

Tracy (38) noted that the early Maxwell containers resembled a drinking glass and were sterilized by dipping in hot paraffin at 220° F.

The first extensive use of a paper milk container was in New York City in 1929. With the recent development of store selling of milk, there has come a demand for an inexpensive single service type of milk container.

Prucha (30) studied the papermaking process and its relation to the sanitary aspect of the container. He took 2 inch square samples of paper as they left the hot dryer rollers, placed them in 100 ml. of sterile water and shook well. Plating of these samples gave no colonies on a 1:1 dilution. He also make tests to determine how long bacteria will survive on impregnated strips of paper. Heavily innoculated strips of paraffined paper were examined daily. No living bacteria were found on the strips after the seventh day. When unparaffined strips were innoculated and examined in the same manner, no viable bacteria were present after the sixth day.

Appling, et al. (5) in discussing paper food packaging materials noted that a few organisms are introduced in the early phases of paper or paper board manufacture, but practically all are eliminated through the chemical and physical operations necessary in the manufacture of the product. The application of chemicals takes place in the form of strongly acid or alkaline cooking liquors at the digesters, liquors such as chlorine or peroxides at the bleachers and alum at the paper machine. The primary physical factor which reduces microorganisms is heat at the digesters, grinders, drier rolls, and during waxing operations.

Casey (7) stated that recent developments in the use of paper containers for milk and other food products where highly sanitary conditions should be maintained have brought the subject of paper mill microbiology to the attention of the health authorities.

Tanner (36) felt that (a) paper was devoid of bacteria which had sanitary significance, (b) pathogenic bacteria could not survive the operations used in making paper, (c) the only bacteria present in paper were harmless aerobic spore-forming species widespread in nature, and (d) coliform bacteria were absent in milk containers.

Stark (35) noted that paper milk containers have never been incriminated in any outbreak of disease is convincing evidence of their public safety.

Sanborn (34) indicated that the influence of calander water is a good example of a source of growth that is controllable. He proposed standards (33) for paper milk containers: (a) use virgin pulp only, (b) use pure process water with (c) suitable protection and wrapping of finished board, (d) mechanical handling during converting, and (e) good plant sanitation. Samples prior to moisture proofing should not have a count exceeding five hundred colonies per gram of disintegrated board.

The Guide for Sanitation Standards (4) gives bacterial standards which are now effective under the Grade A Pasteurized Milk Ordinance. Paper stock shall meet the bacterial standard of not more than 250 colonies per gram as determined by the disintegration test. The residual bacterial count of single service containers and closures used

for pasteurized milk and milk products shall not exceed one colony per ml. of capacity or not over 50 colonies per eight square inches of a product contact surface in three out of four samples taken at random on a given day. All single service containers shall be free of coliform organisms.

Referring to carton structure, Hedrick and Hall (13) stated that the container must be sufficiently durable to provide a long shelf-life without affecting the flavor of the product.

Griffin, et al. (10) tested flexible films to determine their ability to provide a barrier to bacterial penetration. They found that there were no signs of penetration by bacteria by any means except through film defects. Whenever bacterial penetration was noted, a pinhole or minute tear was found. There were no signs of diffusion or "grow-through" types of penetration.

Bauermann, et al. (6) noted the multiplicity of food packaging materials for today's food products is so great that the selection of a package for a given food entails a great deal of work and testing. Food is packaged for five primary reasons: (a) to protect the product from contamination from microorganisms and filth, (b) to retard or prevent loss or gain of moisture, (c) to shield the product from oxygen and light, (d) to facilitate handling, and (e) to enhance the marketability of the product.

EXPERIMENTAL PROCEDURE

Two basic carton structures were used. The first was the standard carton now used in the dairy industry. This was a laminated structure with medium density polyethylene coating on either sides of a solid bleached sulphite paperboard. Basis weight of the paperboard was 215 pounds. The interior polyethylene coating was approximately 1.5 mils, the exterior coating 0.8 mils. The side seam construction was such that a raw edge of paper was exposed on the inside of the carton.

The second structure was a foil laminated carton. It was identical to the first but with two additional laminations. Thus from the outside to the inside the laminations were 0.8 mils polyethylene, paperboard, 0.8 polyethylene, .00035 zero temper oil free aluminum foil, and 1.5 mils polyethylene. Variations of the two basic cartons were considered. First, by a process of skiving and rolling, the raw edge on the inside side seam of the carton was eliminated. Second, cartons were sterilized using ethylene oxide gas.

Whole Milk Flavor Evaluation Test

In three separate trials, sterilized and pasteurized milk was packaged in Pure-Pak style milk containers using the Ex-Cell-0 NLL machine at Michigan State University. Six variations of the basic Pure-Pak design were used. They were:

1. Regular plastic coated carton.

2. Regular plastic coated carton with skived and rolled inner seam.
3. Regular plastic coated carton sterilized with ethylene oxide gas.
4. Foil laminated plastic coated carton.
5. Foil laminated plastic coated carton with skived and rolled inner seam.
6. Foil laminated plastic coated carton sterilized with ethylene oxide gas.

These six variations are types which are presently in use. Types other than the regular plastic coated carton are for special products such as syrups, dry, or sterile products.

Whole milk from the Michigan State University dairy herd was used. The milk to be sterilized was processed through a Cherry-Burrell Unitherm at a temperature of 298° F. The holding time was 8 sec. Following sterilization the milk was homogenized, cooled to 60° F., piped directly to the Ex-Cell-0 NLL aseptic filler where the filling was accomplished.

The processing equipment used was cleaned, sanitized with a 200 ppm chlorine solution, then steamed at 10 psi for two hours. The only piece of equipment which did not receive the steaming treatment was the pasteurizing vat.

The pasteurized milk was processed at 150° F. for 30 minutes, homogenized at 2000 psi, cooled to 50° F. in a plate heat exchanger, and then moved to the sterile surge tank. From the sterile surge tank, the product flowed by gravity to the Ex-Cell-0 aseptic filler where the filling was accomplished.

Immediately after filling, the cartons were placed in metal cases, 24 quarts to a case. They were then transported to Ohio State University where they were stored in the University Dairy cooler at 42° F. A flavor evaluation was made by members of the Department of Dairy Technology staff at one week intervals using organoleptic methods. The scoring ranges used and flavor defects noted were those recommended by The American Dairy Science Association and are in common use in the dairy industry.

This evaluation was continued until the milk became unsaleable.

1% Lactic Acid Static Storage Test

A standard test for the laboratory testing of carton integrity involves the use of a 1% solution of lactic acid in water. This simulates the action of hard-to-hold products such as orange juice. Carton deterioration or leaks may be noted and bulge measurements made.

Pure-Pak cartons which had been previously bottom formed were filled by hand with a 1% lactic acid solution of water, then top sealed using a hand operated bench top sealing unit. Four variations of the

basic Pure-Pak design were used. They were:

1. Regular plastic coated carton
2. Regular plastic coated carton with a skived and rolled inner seam
3. Foil laminated plastic coated carton
4. Foil laminated plastic coated carton with a skived and rolled inner seam

The cartons were then placed in two types of cases. One was a standard wire case holding 16 quarts. The other was an RSC corrugated case, 275 pound test, C flute, holding 12 quarts. Cartons in both style cases were held at 42° F. for one week. At the end of one week the cartons were removed from the cases and placed in a free standing unsupported condition. Measurements were made from front to back and side to side at point of maximum bulge with a pair of calipers. These measurements were made at 0, 3, 5, 7, 10, 14, and 17 days.

1% Lactic Acid Transportation Test

Using the same filling and sealing procedures and carton variations as in the static storage test, the filled cartons were packed in RSC corrugated cases, 275 pound test, C flute. Cartons in these cases were held for one week at 42° F. They were removed from the cooler, placed on a truck, and subjected to a 510 mile round trip. This was from Cleveland, Ohio to Flint, Michigan and return. During the trip the cartons were subjected to vibration and handling similar to that experienced in a dairy distribution system. The cartons in the cases were

returned to the cooler and held for an additional five weeks. At the end of this time, the cartons were removed from the cases and placed in a free standing unsupported condition. Measurements were made as in the static storage test at intervals of 0, 3, 5, 7, 10, 14, and 17 days.

Pour Grasp Firmness Test

At the end of the 17 days holding period, the four basic carton variations were emptied by opening the pitcher pour spout but leaving the remainder of the gable unopened. The "pour grasp" firmness of each variation was tested. In this test, the carton is placed in a standing position with one side touching a rail. By moving a switch, a plunger is activated which moves out to contact the carton on the opposite side from the rail, thus simulating the thumb and finger grip normally used when holding a milk container. A gauge indicates the pressure in pounds necessary to break the vertical dimension of the carton.

Microbiological Examination of Finished Plastic Coated Milk Containers

Full cases of cartons were selected at random from the production line just prior to warehousing. All twelve corner edges of the shipping container were taped prior to shipment for evaluation. Samples were taken over a six-month period.

Microbiological counts were made by the swab test. In this test, a sterile cotton swab contacts a known area of the carton to be examined. The swab is placed in sterile water, shaken and aliquots plated in nutrient agar. Incubation is at 90 or 98^{o} F. for 48 hours.

RESULTS

Whole Milk Flavor Evaluation Test

The results of the whole milk flavor test are summarized in Tables 1 - 4. If post-pasteurization contamination can be eliminated by sterilization of equipment and the use of an aseptic filler and the product moved in a refrigerated system then the ability of the carton to protect and contain the product for a longer period is of importance. This test was to determine the relative ability of various carton structures to protect and contain the product. If no psychrophilic organisms were present, the shelf-life should be extended. The foil laminated carton, sterilized with ethylene oxide gas was used as a control. This carton should not contribute any organisms to the product and give the best barrier protection. The skived and rolled edge used on both regular and foil cartons should prevent moisture penetration of the side seam, thereby contributing to the strength and bacteriological integrity of the carton.

It was anticipated that chemical and/or enzymatic changes would be the limiting factor of shelf-life. The sterilized product was included as a control. Table 1 gives the initial flavor scores. In all cases, the pasteurized samples scored higher than the sterilized. The pasteurized milk was criticized as having a "feed" flavor. This is a common defect of pasteurized milk and is due to a carry-over of feeds such as silage into the milk. The sterilized milk was scored "astringent."

There was a variation in initial flavor scores and bacteria counts from trial to trial. The sterilized milk samples were not sterile.

Tables 2, 3, and 4 give the flavor scores for all carton structures. Flavor scores of the pasteurized milk were above those of sterilized product. The average scores in each trial of pasteurized milk for all types of cartons were 39.05, 37.93, and 38.57 after one week of storage. Sterilized samples scored 38.36, 37.47, and 37.73. The average for all pasteurized samples was 38.52. The average for all sterilized samples was 37.85.

For the third week, pasteurized averages were 38.49, 36.66, and 38.88. Sterilized samples had average scores of 37.58, 37.05, and 34.27. The average third week pasteurized flavor score was 38.14, that of the sterilized samples was 36.36. At the fourth week, however, the average sterilized score was higher than the pasteurized being 36.53 and 35.23.

At four weeks all types of regular pasteurized carton scores averaged 35.85. All foil pasteurized carton scores averaged 34.58. For sterile milk at four weeks, regular cartons of all types scored 36.67, foil cartons 36.39.

For pasteurized milk no one style carton gave a considerably higher score. At four weeks, the sterile foil carton had the highest score in Table 2, the skived regular in Table 3, and the sterile regular carton in Table 3. Neither did any particular style carton give a consistently lower score.

By the end of the fifth week bacterial counts in the milk from all packages exceeded 300,000/ml. Off-flavors noted were bitter, yeasty, fruity, and astringent.

1% Lactic Acid Static Storage Test

In the 1% lactic acid static storage test, the bulge characteristics of four carton variations were studied in relation to casing tightness. A comparison was made between a metal case and a corrugated case. The metal case used was a standard wire Pure-Pak case holding 16 quarts. The interior dimensions were 12.25 inches x 12.25 inches which gives a case space per carton of 3.06 inches. This is 0.31 inches over the square dimension of the carton.

The corrugated case used had an interior measurement of 11.75 inches x 8.54 inches. This gives a case space per carton of 2.90 inches and is 0.15 inches over the square dimension of the carton. Thus, the corrugated case held the cartons in a more confined condition, 0.16 inches.

Results of this study are shown in Tables 5, 6, and 7.

In the industry, carton bulge values are generally given in 1/32 inches over the square dimension of the carton. Thus a value of 5.0 in the tables would indicate a 5/32 inch bulge over the nominal side carton dimension of 2-3/4 inches.

In Table 5, the regular cartons, both plain seam and skived have a value of 7.0, the foil cartons a value of 6.0. By the seventh day, the regular cartons have increased in size to 8.6 and 8.3 respectively and at seventeen days, 10.8 and 10.6. The foil cartons at seven days have

values of 8.3 and 8.1, at seventeen days, 10.4 and 10.0. For the first week in a free standing condition, the foil cartons, regular and skived increased in size more than the regular cartons. The regular cartons had a seven day increase of 1.6 and 1.5, the foil cartons 2.3 and 2.1. At seventeen days there was less than 1.32 inches variation in all types of regular and foil. The foil cartons while showing slightly lower values, had greater increases from zero to seventeen days.

Table 6 gives the values obtained using the corrugated case. The regular cartons had initial values of 5.0, the foil cartons 4.0.

At seven days the regular cartons had values of 8.1 and 8.3, the foil cartons 7.3 and 7.5. The seven day increases were 3.1, 3.3, 3.3, and 3.5. At seventeen days, the regular cartons measured 10.4 and 10.0, the foil cartons 9.8 and 9.4. There was 1/32 inches difference between the regular carton with raw edge and the foil carton with skived edge. Increases in bulge ranged from 5.0 to 5.8.

Initial values were higher with the more loosely cased cartons. As shown in Table 7 however, the more tightly cased cartons had a greater increase in bulge at both seven and seventeen days. Final dimensions of all cartons tested varied from 0.4 to 0.6.

1% Lactic Acid Transportation Test

In the transport study, the initial free standing values ranged from 7.6 for the regular carton to 6.6 for the skived foil carton. The increase in bulge from zero days to three days was significant, being

1.7 to 1.9. The skived foil had the greatest increase. At seventeen days the regular carton had a value of 11.9, an increase of 4.3; regular skived was 11.3, an increase of 4.6. The foil cartons were slightly lower; the foil carton measured 11.5, an increase of 5.1; the foil skived, 11.1, an increase of 4.5. There was less than 1/32 inches differences in the final measurements. The transportation test showed final values slightly higher than in the other cased tests. Greater increase in bulge was obtained in the first three days with the transportation test than with either cased study.

Pour Grasp Firmness Test

Results of the pour grasp firmness test are shown in Table 9. Cartons stored in corrugated cases had a slightly better pour grasp firmness than did their like cartons stored in wire cases. Cartons with skived seams were slightly better in pour grasp firmness than their like cartons with a regular seam. Foil lined cartons had a significantly better pour grasp firmness than their respective regular cartons. Values for regular cartons ranged from 5.8 to 6.3 pounds while foil cartons were 8.9 to 9.3 pounds. The six week storage cartons had a slightly lower pour grasp firmness than the other cartons tested.

Microbiological Examination of Finished Cartons

Results of the microbiological examination are summarized in Table 10. In all, 1050 samples were examined. Of these, 28 showed bacteria counts ranging from one to six per carton assuming 52 square centimeters per test.

Five cartons had a count of one, two a count of three, eleven a count of four, and ten a count of six. This gives a total count of 115 colonies in 1050 samples or a count of 0.11 per sample.

TABLES

TABLE 1

Initial Standard Plate Counts and Flavor Scores
of
Whole Milk Flavor Test

Trial	Pasteurized Milk		Sterilized Milk	
	Initial SPC	Initial Flavor	Initial SPC	Initial Flavor
1	300-600/ml.	38.0 - 39.0	100-400/ml.	37.0 - 38.5
2	3,000/ml.	37.5 - 39.0	100-300/ml.	37.0 - 38.0
3	800-17,000/ml.	38.0 - 39.5	100-1300/ml.	37.0 - 38.0

TABLE 2

Summary Scorecard for Long Life Milk 7-19-68

Samples	Flavor Score at Following Times of Storage (Weeks) 1 (1 wk after receiving) Range	Ave	3 Range	Ave	4 Range	Ave
Pasteurized						
R-P	38.5-39	38.83	38.5-40	39.16	32-36	33.33
SR-P	37.5-38.5	37.83	36-38	37.33	30-32.5	31.5
KR-P	39-39.5	39.16	39-40	39.33	35-37.5	36.33
KF-P	38-38.5	38.16	35.5-37.5	36.83	30-33.5	31.16
F-P	39-39.5	39.16	38.5-40	39.16	32-36	34.66
SF-P	39-39.5	39.16	38.5-40	39.16	36-37.5	36.66
Sterilized						
R-S	38-39	38.33	35-38	36.66	37-38	37.66
SR-S	38-38.5	38.16	38-38.5	38.33	37-38	37.66
KR-S	38-38.5	38.16	36-38.5	37.5	37-38	37.50
KF-S	39	39.00	36.5-38	37.16	37-38	37.66
F-S	38-38.5	38.16	36.5-38	37.5	36.5-39	37.83
SF-S	38-38.5	38.33	38-39	38.33	36.5-38.5	37.33

No flavor analysis made at two weeks due to workload.

Four samples of each type were evaluated.

Legend

R Regular
K Skived
S Sterile
F Foil
P Pasteurized
-S Sterile Milk

TABLE 3

Summary Scorecard for Long Life Milk 7-24-68

Samples	Flavor Score at Following Times of Storage (Weeks) 1 (1 week after receiving)		3		4	
	Range	Ave	Range	Ave	Range	Ave
Pasteurized						
R-P	37-38	37.50	37.5-38	37.66	35	36.00
SR-P	37.5-38	37.83	37-38.5	37.66	33-36	34.50
KR-P	37-38.5	38.00	37-38.5	37.83	35.5-36.5	36.00
KF-P	38-38.5	38.16	32-34	33.33	30-32	31.00
F-P	38-38.5	38.16	35.5-36	35.83	25-32	28.5
SF-P			37-38	37.66	32-36	34.00
Sterilized						
R-S	37-38	37.50	37-37.5	37.33	36.5-37.5	37.00
SR-S	37.38	37.50	37-38	37.50	36-37	36.50
KR-S	37-37.5	37.33	36.5-37.5	37.00	37-37.5	37.25
KF-S	37-38	37.33	36.5-38	37.16	35-37	36.00
F-S	37-39	38.16	36.5-37	36.66	36-36.5	36.25
SF-S	36-37.5	37.00	36-38	36.66	36.5-37.5	37.00

No flavor analysis made at two weeks due to workload.

Four samples of each type were evaluated.

Legend

R Regular
K Skived
S Sterile
F Foil
P Pasteurized
-S Sterile Milk

TABLE 4

Summary Scorecard for Long Life Milk 7-31-68

Samples	Flavor Score at Following Times of Storage (Weeks) 1 (1 week after receiving)		2		3		4		6	
	Range	Ave	Range	Ave	Range	Ave	Range	Ave	Range	Ave
Pasteurized										
R-P	37-39	38.00	38-40	38.33	38.5-40	39.16	37.5-38.5	38.16	36.5-38	37.25
SR-P	37.5-39	38.33	39-39.5	39.16	38-40	38.33	39-40	39.33	33-36	34.50
KR-P	38.5-39	38.66	38.5-40	39.00	38-39.5	38.66	37.5-40	38.50	33-36	34.50
KF-P	39-39.5	39.16	38.5-39.5	39.16	38-39	38.50	38.5-39	38.83	35-37.5	36.25
F-P	38-39	38.50	39-40	39.5	39-39.5	39.16	38.5-39	38.66	32	32.00
SF-P	38-39.5	38.83	39-40	39.5	38.5-40	39.00	37.5-39.5	38.66	38-38.5	38.25
Sterilized										
R-S	37-38	37.50	37-38.5	37.83	36.5-38	37.16	30-32	31.00	35-37.5	36.25
SR-S	37-38	37.66	33-35	34.00	30-33	31.00	37-38	37.66	36.5-37	36.75
KR-S	37-38	37.66	37.5-38.5	38.00	35-37.5	36.16	37.5-38	37.83	37.5-38	37.75
KF-S	37.5-38	37.83	37.5-39	38.16	37-39	38.00	36.5-38	37.33	30-32	31.00
F-S	38-38.5	37.5	36.5-38	37.16	30-33	31.66	30-32	30.66	34	34.00
SF-S	36-38.5	37.5	36-36.5	36.16	30-33	31.66	37-38	37.66	35.5-37	36.25

See Legend on Table 2.

No flavor analysis made at five weeks due to workload.

Four samples of each type were evaluated.

TABLE 5

1% Lactic Acid Static Bulge Test

Cartons Held In Metal Case For One Week After Filling
Then Out Of Case To a Free Standing Position-
Room Temperature

	Days Free Standing						
	0	3	5	7	10	14	17
Carton Style							
Regular	7.0	7.5	8.0	8.6	9.6	10.3	10.8
Regular-Skived	7.0	7.5	8.0	8.5	9.3	10.0	10.6
Foil	6.0	6.5	7.3	8.3	9.1	9.8	10.4
Foil-Skived	6.0	6.1	7.1	8.1	9.0	9.6	10.0

Quantities shown are averages of six cartons for each carton type.

Measurements given in 1/32 inches over square dimension of carton. Carton measurement is 2-3/4 inches.

TABLE 6

1% Lactic Acid Static Bulge Test

Cartons Held in Corrugated Case for One Week After Filling
Then Out of Case to a Free Standing Position-
Room Temperature

	Days Free Standing						
	0	3	5	7	10	14	17
Carton Style							
Regular	5.0	6.6	7.8	8.1	9.5	10.0	10.4
Regular-Skived	5.0	6.5	7.0	8.3	9.0	9.5	10.0
Foil	4.0	5.3	6.5	7.3	8.6	9.0	9.8
Foil-Skived	4.0	5.0	6.3	7.5	8.0	8.6	9.4

Quantities shown are averages of six cartons for each carton type.

Measurements given in 1/32 inches over square dimension of carton. Carton measurement is 2-3/4 inches.

TABLE 7

1% Lactic Acid Static Bulge Test

Comparison of Metal and Corrugated Cased Cartons

Carton Style	Bulge Increase Over Initial Free Standing Value			
	7 Days		17 Days	
	Metal	Corrugated	Metal	Corrugated
Regular	1.4	3.1	3.8	5.4
Regular-Skived	1.3	3.3	3.6	5.0
Foil	2.3	3.3	4.4	5.8
Foil-Skived	2.1	3.5	4.0	5.4

Quantities shown are averages of six cartons per each carton type.

Measurements given in 1/32 inches over square dimension of carton. Carton measurement is 2-3/4 inches.

TABLE 8

1% Lactic Acid Transportation Bulge Test

Carton Style	Days Free Standing at Room Temperature 0	3	5	7	10	14	17
Regular	7.6	9.3			10.8	11.0	11.9
Regular-Skived	7.3	9.0			10.4	10.9	11.7
Foil	6.4	8.7	9.3	9.7	10.0	10.7	11.5
Foil Skived	6.6	8.5			9.5	10.3	11.1

Quantities shown are averages of fifteen cartons of each carton type.

Measurements given in 1/32 inches over square dimension of carton. Carton measurement is 2-3/4 inches.

TABLE 9

Pour Grasp Firmness Test

Carton Style	Metal Case One Week Storage 17 Days "Free"	Corrugated Case One Week Storage 17 Days "Free"	Corrugated Case Six Weeks Storage Transport 500 mi. 17 Days "Free"
Regular	5.8	6.3	5.2
Regular-Skived	5.9	6.2	5.6
Foil	9.1	9.3	8.4
Foil-Skived	8.9	9.3	8.7

Firmness in Pounds

Quantities shown are averages of six cartons for each carton type.

TABLE 10

Bacteriological Examination of Finished Plastic Coated Cartons

Areas Tested in Square Centimeters	Method Used	Number of Items Tested	Bacterial Count Per Item						Number* Exceeding Standard	Coliform Test
			1	2	3	4	5	6		
52	Swab	1,050	5	0	2	11	0	10	0	Neg

*Based on Standard of one colony per ml. of capacity or not over 50 colonies per 8 square inches (1 per square centimeter)

DISCUSSION

A review of the literature indicates two approaches for the processing and packaging of milk and milk products to meet the needs of the domestic dairy industry today for a longer shelf-life.

With milk product heating systems now available it is possible to produce a sterile product. The aseptic Tetra-Pak and Ex-Cell-0 packaging systems are in successful operation. This does not mean that the present methods of pasteurization either normal or UHT cannot be included in an overall system which will give the shelf-life needed.

The first would be a completely sterile system with UHT sterilization of the product combined with an aseptic packaging system. This would give a product which would lend itself to long shelf-life handling with or without refrigeration. There may, however, be some problems involved in this approach. The heated flavor of the product could meet with resistance by the American consumer who is more used to the flavor of normally pasteurized milk. The packaging cost of the special carton needed for aseptic use would be greater than for a standard plastic coated carton.

A second approach has been suggested. It involves the use of existing heat treatment practices, perhaps a little higher but still well below the sterile range, improved plant sanitation, and environment control at the filler. This would reduce post-pasteurization contamination and thus give the longer shelf-life needed.

In this system, the adequacy of the present plastic coated Pure-Pak carton from a product protection, strength, and microbiological standpoint must be determined.

In the whole milk flavor evaluation tests the existing carton with and without modifications was evaluated. A flavor score of 36.0 or less was considered unsaleable. The use of a skived side seam, additional foil lamination, or ethylene oxide treated carton did not give any advantages in keeping quality or flavor retention of a pasteurized product during the first four weeks. No relationship could be noted between product failure and package type. The only physical carton failure occurred in a regular carton with normal side seam and it failed at the side seam after seven weeks.

The consumer can make a value judgment of a product by the appearance of the package itself. The purpose of the bulge test series was to evaluate the various carton structures available. By holding in a cased condition for one week, then placing the carton in a free standing condition, an attempt was made to simulate actual handling procedures in which a product would be produced, stored, delivered, and put in a dairy case for sale. By Ex-Cell-0 standards, a carton is considered saleable if it has a bulge of 14.0 or less. This would be 14/32 inches. None of the cartons approached this limit after seventeen days free standing. The highest value was 10.8 for a standard carton with a

regular side seam. The actual difference between the various carton structures was 1/32 inches or less and could be considered insignificant. Of interest was the fact that in both tests the foil cartons had lower initial values but tended to bulge at a greater rate than the regular carton. This was not expected as foil does not have the elongation tendencies of paper or plastic.

Initial values of the more tightly cased cartons were lower initially but tended to bulge at a faster rate. Final measurements were slightly lower, in the range of 1/64 inches. This could be considered insignificant. The conclusion was that tighter casing gave only a temporary effect.

In the transportation test, the storage, transport, and restorage of long life product was simulated. Initial bulge values were higher than in the static storage tests. This would be expected. Two factors are involved. Vibration during the 500 mile trip could soften the carton. The cartons when placed in a free standing position were five weeks older and had a longer time to be affected by the 1% lactic acid solution. Though the values were higher they were still well within the Ex-Cell-O limits of 14.0.

In all three bulge tests, seventeen day values followed the same pattern. The regular carton had the greatest bulge, the skived foil the least but in no case did it exceed 1.0.

The "pour grasp" firmness test is a routine test to evaluate the softness of the carton after exposure to a free standing condition. It was in this test that significant differences were noted between regular and foil cartons. In all three casing situations the foil cartons had values of 3.0 to 3.2 pounds greater than the regular cartons. As this measurement is made at a vertical score line, the rigidity of the foil at the fold must contribute to the values observed. The relationship noted in the bulge test were observed here in that the cartons tightly cased had the highest values, the six week old cartons, the lowest.

A great deal of study was given to the sanitary aspect of the milk carton when it came into general use in the 1930's. It was determined that the microbiological population of paperboard was made up mainly of organisms which could survive the heat experienced in the papermaking operation. Pathogens were destroyed and as psychrophiles are heat liable, it was assumed that they did not survive. Also, at this time, the Pure-Pak blank was wax coated at the machine. The wax temperatures used and the coating itself tended to destroy or cover any organisms present.

The test results indicate an extremely low microbial population. Of 1,050 items tested, 28 showed the presence of organisms. This was a swab test and showed organisms on the surface. The test was a standard plate count at 97° F. While the standard plate count is the

one used in the industry, a test at 40° F. would give a more accurate evaluation of the presence of psychrophilic organisms.

SUMMARY AND CONCLUSION

The project was conducted to determine the feasibility of adapting the Pure-Pak carton in its present form or with modifications as a package for extended shelf-life milk and milk products. It has been demonstrated that with suitable sanitation practices and environment control at the filler an extended shelf-life milk is attainable using normal pasteurizing temperatures. This combined with refrigerated handling gives the consumer the advantage of a fluid milk product with both good keeping quality and a fresh palatable flavor.

Results of the study showed that the regular plastic coated carton would perform in a generally satisfactory manner under the conditions tested. In the whole Milk Flavor Evaluation Test the cartons were held in a cooler with no strong odors. The bulge tests were stored in a dry cooler and kept in a dry condition during their "free standing" test.

In an analysis of variance it was shown that (a) the days of free standing represents a significant variable at the 1% level; (b) the difference between the results for cartons held in corrugated or metal cases is a significant variable at the 1% level; (c) a significant difference exists due to the variable factor in carton types; (d) none of the interaction terms were significant, suggesting that the bulging with time followed parallel courses for each carton regardless of casing.

A further examination of the data reveals that (a) there is no significant differences between regular versus regular skived cartons;

(b) there is no significant difference between foil versus foil skived cartons, and (c) that there is a significant difference between regular and regular skived cartons as a group versus foil and foil skived cartons as a group.

Even though some of these differences between carton structures were statistically significant it would appear that all values obtained were well within the performance limits accepted by the industry and that the cartons would perform adequately in actual use. The maximum bulge normally allowed for a carton to be considered saleable is 14/32 inches. The maximum value obtained in any test was 11.9.

In the flavor and bulge tests, various carton structures were tested. In each test, the regular carton performed adequately. Somewhat better results were obtained with the use of a skived edge and/or a foil lamination. The cost of skiving is nominal but the use of a foil laminate increases the cost significantly.

The ability of a carton to withstand storage, handling, and vibration was studied in the transportation test. All carton structures performed well. The regular carton showed bulge dimensions well within the limits allowed.

It was in the area of pour grasp firmness that the most significant difference between a regular and a foil carton was noted. Values of the foil cartons were approximately 50% higher than those of the regular carton. It would be well to investigate this area more thoroughly to determine customer reaction.

Bacteriologically, the regular carton without ethylene oxide sterilization appears to be a suitable container for extended shelf-life pasteurized milk. The counts obtained by useof the swab test showed very low levels of contamination.

These tests were, however, conducted at 98° F. and this is not the optimum temperature for the growth of psychrophilic organisms which are our main factor in spoilage. Organisms present in paperboard have survived the heat treatment received in the paper-making process. These are spore-formers or thermoduric types. It would seem advisable to make routine, the bacteriological examination of paperboard for psychrophilic organisms if it is to be used for extended shelf-life products.

LITERATURE CITED

(1) Anon. Aseptically Processed Dairy Products. Dairy and Ice Cream Field, 151: (3) 1968.

(2) Anon. Contamination Control Principles. National Aeronautics and Space Administration, NASA SP-5045. 1967.

(3) Anon. Grade A Pasteurized Milk Ordinance. U. S. Public Health Service. U. S. Dept. of Health, Education, and Welfare. 1965.

(4) Anon. Fabrication of Single Service Containers and Closures for Milk and Milk Products. U. S. Public Health Service. U. S. Dept. of Health, Education, and Welfare. 1966.

(5) Appling, J. W. Microbiology of Pulp and Paper. TAPPI Monograph Series No. 15. 1955.

(6) Bauermann, J. F., Dunham, W. C., Hayes, K. M., Johnstone, W. F., Leed, T. W., Stiles, P. G., and Swank, C. E. Food Product Development and Distribution. Northeast Extension Marketing Committee Publication. 1968.

(7) Casey, J. R. Pulp and Paper, Vol. 2 Papermaking, 1960

(8) Elliker, P. R. A Way to Better Keeping Quality of Dairy Products. Presented at the Washington Institute of Dairying. March, 1962.

(9) Gould, I. A. Compounds Formed by the Heat Treatment of Milk. Scientific Article #1-51. Dept. of Dairy Tech. The Ohio State University, Columbus, Ohio. 1951.

(10) Griffin, R. G., Nosrati, M. H., Lampi, R. A., Szczeblowski, J. S., Bacterial Resistance of Film. Modern Packaging, 40: (14) 164-167. 1967.

(11) Harper, J. Personal Correspondence, Dept. of Dairy Tech. Ohio State University, Columbus, Ohio. 1968.

(12) Hedrick, T. I. Advances In The Sterilization and Aseptic Packaging of Fluid Products. Paper presented at 26th Annual Milk Manufacturers Conf. Michigan State University, E. Lansing, Michigan. 1966.

LITERATURE CITED

(13) Hedrick, T. I. and Hall, C. W. Aseptic Filling of Cartons. Dairy Engineering, 78: (7) 248-250. 1961.

(14) Hedrick, T. I., Heldman, D. R., and Hall, C. W. Controlling Product Contamination. The Milk Dealer 54: (2) M 8, M 15. 1964.

(15) Heldman, D. R. Air-borned Microorganism Populations in Food Packaging Areas. J. Milk Food Tech., 27: (8) 245-251. 1964.

(16) Heldman, D. R., Hedrick, T. I., and Hall, C. W. Controlling Air Contamination Using Laminar Air Flow. Paper presented at the Thirteenth Annual National Dairy Engineering Conference, Michigan State University, E. Lansing, Mich. 1965.

(17) Herried, E. O. New Facts Concerning The Physical, Chemical and Storage Stability of Sterilized Milk and Cream. Paper presented at 58th Meeting of Milk Industry Foundation, Montreal, Canada. 1965.

(18) Holland, R. F. A Method for Sterilized Milk. Am. Milk Rev., 26: (12) 40, 45, 70, 71. 1964.

(19) Holland, R. F. How Heat Affects Milk Constituents. Am. Dairy Rev., 27: (4) 46, 48, 112. 1965.

(20) Irvin, H. A Dairy Sanitarian Takes a Look at Sterilization of Milk and Milk Products. Am. Dairy Rev., 30: (5) 88-91. 1968.

(21) Johnson, F. D. Solving Problems of Long Life Milk. Can. Dairy Ice Cream Journal, 45: (10) 35-36. 1966.

(22) Jordan, W. K. Sterilization and Aseptic Packaging of Milk Products - Changes in Products. J. Dairy Sci., 51: (7) 1144-1151. 1968.

(23) Lisiecki, R. 60 Day Shelf Life Dairy Products. Kansas State Univ., Lawrence, Kansas. Paper presented at the Dairy Industries Conference. March, 1969.

(24) Lisiecki, R. Personal Correspondence. 1968.

LITERATURE CITED

(25) Mann, E. J. Aseptic Packaging of Milk and Milk Products. Dairy Industries, 34: (1) 30-31. 1969.

(26) Mann, E. J. Major Developments in Dairy Technology. Dairy Industries, 31: (6). 1966.

(27) Olsen, J. C. The Keeping Quality of Pasteurized Milk as Influenced by the Growth of Psychrophilic Bacteria and the Addition of Aureomycin. J. Milk Food Tech., 16: (5) 213-219. 1958.

(28) O'Sullivan, A. C. and Keogh, M. K. Ultra High Temperature Whipping Cream. J. Dairy Sci., 51: (8) 1324-1329. 1968.

(29) Overcast, W. W. Extending Shelf Life by Controlling Psychrophiles. Am. Dairy Rev. 29: (9) 42, 44, 46, 48. 1967.

(30) Prucha, M. J. Sanitary Aspects of Paper Milk Containers. J. of Milk Tech., 1: (2) 4-9. 1938.

(31) Randolph, H. E., Freeman, T. R., and Peterson, R. W. Keeping Quality of Market Milk Obtained at Retail Outlets and at Processing Plants. J. Milk Food Tech. 28: (2) 92-96. 1964.

(32) Read, R. B., Jr., Dickerson, R. W., Jr., and Thompson, H. E., Jr. Time-Temperature Standards for the Ultra-High Temperature Pasteurization of Grade A Milk and Milk Products by Plate Heat Exchange. J. Milk Food Tech., 31: (3) 72-74. 1968.

(33) Sanborn, J. R. Proposed Standards for Paper Milk Containers. J. of Milk Tech., 1: (2) 41-45. 1938.

(34) Sanborn, J. R. Public Health Compliance by Manufacturers of Paper for Packaging Perishable Foods. J. of Milk Tech., 5: (1) 88-93. 1942.

(35) Stark, C. N. Sanitary Regulations for Controlling the Production of Paper Containers for Milk. J. of Milk Tech., 4: (4). 1941.

(36) Tanner, F. W. Paper and Paperboard in the Food Industry - An Analysis of Literature and Appraisal of Their Sanitary Condition. J. Milk Food Tech., 11: (6) 334-345. 1948.

LITERATURE CITED

(37) Thomas, S. B. Psychrophylic Organisms in Milk and Dairy Products. Part I. Review Article No. 70. Dairy Science Abstracts 20: (5) 354-371. 1958.

(38) Tracy, P. H. Certain Practical Aspects of the Use of Paper Milk Containers. J. of Milk Tech., 1: (3) 40-42. 1938.

APPENDIX

APPENDIX

Experimental Data for Table 5

1% Lactic Acid Static Bulge Test, Metal Case

Carton Style	Days Free Standing 0	3	5	7	10	14	17
Regular	7	7	8	8	10	10	10
	7	7	8	8	10	10	11
	7	7	8	9	10	10	11
	7	8	8	9	9	11	11
	7	8	8	9	9	11	11
	7	8	8	9	10	10	11
	7.0	7.5	8.0	8.6	9.6	10.3	10.8
Regular Skived	7	7	8	8	10	10	11
	7	7	8	8	10	10	11
	7	7	8	8	9	10	11
	7	8	8	9	9	10	11
	7	8	8	9	9	10	10
	7	8	8	9	9	10	10
	7.0	7.5	8.0	8.5	9.3	10.0	10.7
Foil	6	6	7	9	9	10	10
	6	7	7	9	9	10	10
	6	7	8	8	9	9	10
	6	7	8	8	9	10	11
	6	6	7	8	10	10	11
	6	6	7	8	9	10	11
	6.0	6.5	7.3	8.3	9.1	9.8	10.5
Foil Skived	6	6	7	8	9	10	10
	6	7	8	8	9	10	10
	6	6	7	8	9	10	10
	6	6	7	8	9	10	10
	6	6	7	9	9	9	10
	6.0	6.1	7.1	8.1	9.0	9.7	10.0

APPENDIX

Experimental Data for Table 6

1% Lactic Acid Static Bulge Test, Corrugated Case

Carton Style	Days Free Standing						
	0	3	5	7	10	14	17
Regular	5	6	7	8	10	10	10
	5	6	8	8	10	10	10
	5	7	8	8	10	10	11
	5	7	8	8	9	10	11
	5	7	8	9	9	10	11
	5	7	8	8	9	10	11
	5.0	6.6	7.8	8.1	9.5	10.0	10.5
Regular Skived	5	6	7	8	9	10	10
	5	6	7	8	9	10	10
	5	7	8	8	9	9	10
	5	6	8	8	9	9	10
	5	7	8	9	9	10	10
	5	7	8	9	9	9	10
	5.0	6.5	7.0	8.3	9.0	9.5	10.0
Foil	4	5	7	8	9	9	10
	4	5	7	8	9	9	10
	4	5	7	7	9	9	9
	4	6	6	7	9	9	10
	4	6	6	7	8	9	10
	4	5	6	7	8	9	10
	4.0	5.3	6.5	7.3	8.6	9.0	9.8
Foil Skived	4	5	6	8	8	8	10
	4	5	6	8	8	9	10
	4	5	6	7	8	9	9
	4	5	6	8	8	9	10
	4	5	7	7	8	9	9
	4	5	7	7	8	8	9
	4.0	5.0	6.3	7.5	8.0	8.6	9.5

APPENDIX

Experimental Data for Table 8

1% Lactic Acid Transportation Bulge Test

Carton Style	Days Free Standing 0	3	10	14	17
Regular	7	9	10	11	11
	7	9	10	11	11
	7	9	10	11	12
	7	9	11	11	12
	7	9	11	11	12
	7	9	11	11	12
	8	9	11	11	12
	8	9	11	11	12
	8	9	11	11	12
	8	9	11	11	12
	8	10	11	11	12
	8	10	11	11	12
	8	10	11	11	12
	8	10	11	11	12
	8	10	11	11	12
	7.6	9.3	10.8	11.0	11.9
Regular Skived	7	9	10	10	11
	7	9	10	10	11
	7	9	10	11	11
	7	9	10	11	11
	7	9	10	11	11
	7	9	10	11	12
	7	9	10	11	12
	7	9	10	11	12
	7	9	11	11	12
	7	9	11	11	12
	8	9	11	11	12
	8	9	11	11	12
	8	9	11	11	12
	8	9	11	11	12
	8	9	11	11	12
	7.3	9.0	10.4	10.9	11.7

APPENDIX

Experimental Data for Table 8

1% Lactic Acid Transportation Bulge Test

Carton Style	Days Free Standing 0	3	5	7	10	14	17
Foil	6	8	9	9	10	10	11
	6	8	9	9	10	10	11
	6	8	9	9	10	10	11
	6	8	9	9	10	10	11
	6	9	9	10	10	10	11
	6	9	9	10	10	11	11
	6	9	9	10	10	11	11
	6	9	9	10	10	11	11
	6	9	9	10	10	11	12
	7	9	9	10	10	11	12
	7	9	9	10	10	11	12
	7	9	10	10	10	11	12
	7	9	10	10	10	11	12
	7	9	10	10	10	11	12
	7	9	10	10	10	11	12
	6.4	8.7	9.3	9.7	10.0	10.7	11.5
Foil Skived	6	8			10	10	11
	6	8			10	10	11
	6	8			10	10	11
	6	8			10	10	11
	6	8			10	10	11
	7	8			10	10	11
	7	8			10	10	11
	7	8			10	10	11
	7	9			9	10	11
	7	9			9	10	11
	7	9			9	11	11
	7	9			9	11	11
	7	9			9	11	11
	7	9			9	11	12
	7	9			9	11	12
	6.6	8.5			9.5	10.3	11.1

APPENDIX

Statistical Analysis of Variance

Source of Variance		Degrees of Freedom	Sum of Squares	Mean Squares	F Ratio	Significance*
Days	(D)	6	142.21	23.70	483.7	V.S.
Casing	(C)	1	10.28	10.28	209.80	V.S.
Carton Type	(T)	(3)	(9.97)	3.32	67.75	V.S.
Regular vs. Reg-S		1	0.32	0.32	0.65	N.S.
Foil vs. Foil-S		1	0.37	0.37	0.75	N.S.
R+R-S vs. Foil+F-S		1	9.28	9.28	139.4	V.S.
	D x C	6	3.47	0.58	1.18	N.S.
	D x T	18	0.82	0.045	0.91	N.S.
	C x T	3	0.34	0.113	2.31	N.S.
D x C x T (Error)		18	0.89	0.049		
Total		55	167.98	Standard Error: ± 0.22 (individual values)		

* N.S. = Not Significant

V.S. = Very Significant