COST AND PERFORMANCE OF POLYSTYRENE BOXES FOR SHIPPING ICE-PACKED POULTRY

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SUMMARY

Polystyrene foam boxes were developed and tested for shipping ice-packed poultry. Six test truck shipments were made. Although polystyrene foam boxes cost more than wooden boxes, a potential net saving of approximately 4.2 cents per hundredweight can be achieved by packing and shipping ice-packed poultry in polystyrene boxes. This saving results from lower costs of transport, lower costs of package ice, and lower costs of labor for packing and loading polystyrene boxes than for wooden boxes. The lighter weight of the polystyrene boxes and the reduced amount of package ice permits loading more poultry in a truck before the truck reaches legal load limits.

Warehouse receivers and retail butchers liked the polystyrene boxes because they were sanitary and easy to handle, to open, and to empty. But the polystyrene boxes were not so sturdy as the wirebound boxes. Sometimes they broke during transit and when they were not handled carefully.

INTRODUCTION

Since 1951, the Nation's commercial production of broilers has been steadily increasing. In 1966, 2,480 million broilers, or 8,631 million pounds, were produced in the United States.[1] Georgia, where part of this study was made, is the largest producing State; 456 million broilers were produced in 1966.

Eighty percent of U.S. broiler production is shipped ice-packed. In 1966, 70 percent of ice-packed poultry was shipped in wirebound wood-veneer boxes (henceforth referred to as wirebound boxes). The rest of the ice-packed poultry was shipped in water-resistant corrugated fiberboard boxes.

Polystyrene foam is manufactured by a process that expands polystyrene beads about 40 times their original volume and reduces their density from approximately 40 pounds per cubic foot to 1 to 2 pounds per cubic foot. The expanded polystyrene beads are fused together by steam under pressure in a mold to form the polystyrene foam container. Henceforth, polystyrene foam boxes will be referred to as polystyrene boxes.

The lightweight, clean, bright-appearance, and good-insulation characteristics of polystyrene foam offer theoretical advantages for using this material to construct shipping containers for ice-packed poultry.

A recent laboratory study showed performance advantages for ice-packed poultry packed in polystyrene boxes. Thomson and others[2] found: (1) significantly higher breast skin microbial counts on chickens in wirebound boxes with 20 pounds of package ice than in polystyrene boxes with 15 pounds of package ice when stored up to 13 days at 40° F.; (2) significantly greater percentage of ice was lost in the wirebound boxes than in polystyrene boxes when stored up to 6 days at 40°; and (3) significantly greater percentage weight loss of poultry in wirebound boxes than in polystyrene boxes when stored up to 6 days at 40°. May and others[3] found lower poultry weight loss and greater ice retention in wirebound boxes than in fiberboard boxes.

The objectives of the present study were to determine: (1) cost of packing and shipping ice-packed poultry in polystyrene and wirebound boxes, (2) poultry shrinkage and ice melt in polystyrene and

[1] POULTRY AND EGG SITUATION. U.S. Dept. Agr. PES-246, 33 pp. April 1967.

[2] THOMSON, J. E., MERCURI, A. J., and RISSE, L. A. SHIPPING CONTAINERS FOR ICE-PACKED POULTRY—EFFECT ON MICROBIAL COUNTS AND WEIGHTS OF POULTRY AND ICE. U.S. Dept. Agr. Market. Res. Rpt. 811, 12 pp. 1968.

[3] MAY, R. N., POWELL, W. R., and HUDSPETH, J. P. A COMPARISON OF QUALITY OF FRESH CHICKEN PACKED IN VARIOUS CONTAINERS. Ga. Agr. Expt. Sta. Bul., N.S., 168, 19 pp. 1966.

wirebound boxes, and (3) whether polystyrene boxes are sturdy enough for handling and shipping poultry.

A preliminary shipment of ice-packed poultry in polystyrene boxes was made from Georgia to New York in February 1966. This shipment indicated that polystyrene boxes for ice-packed poultry may provide some distinct advantages. The particular box used in this shipment was not designed for ice-packed poultry. A polystyrene box was designed for ice-packed poultry in the spring of 1966.

PROCEDURE

In 1966 and 1967, six truck shipments of ice-packed poultry were made from three processing plants (in Georgia, Alabama, and North Carolina) to six receivers (in New York, Florida, Maryland, California, Michigan, and Ohio). In each shipment, six wirebound and six polystyrene test boxes were packed with birds of comparable quality and size. Each test box was packed with approximately 65 pounds of poultry. The six test wirebound boxes were packed with 20 pounds of crushed ice and the polystyrene boxes with 15 pounds of crushed ice. The poultry and ice were weighed separately at time of packing. The test boxes were loaded in the left corner of the last stack in each of the truck shipments. The rest of each load was loaded with wirebound, polystyrene, or fiberboard boxes. Temperature recorders were placed in each shipment.

At the receiver's warehouse, the test boxes were removed from trucks. The contents were removed from the test boxes, and the weight of poultry and ice was recorded. All the wirebound and polystyrene boxes shipped in each shipment were inspected for damage. Trade reaction was obtained from the six receivers and in some instances from retail-store personnel.

A split-plot experimental design was used to test differences in ice loss and poultry shrinkage in the six shipments.

Cost and time studies were made (on packing poultry in the two types of boxes) in two processing plants. Labor requirements were determined by making time studies. Wage rates and cost of boxes and packing materials were obtained from processors and box manufacturers. Transport costs for shipping polystyrene and wirebound boxes were calculated from truck-operating costs published by the Farmer Cooperative Service, U.S. Department of Agriculture.

DESCRIPTION OF BOXES AND PACKING OPERATIONS

Wirebound

The inside dimensions of the wirebound box were 22 by 16½ by 10⅜ inches, and the outside dimensions were approximately 23 by 17½ by 10⅝ inches. The tare weight of the wirebound boxes averaged 5.5 pounds.

The boxes were constructed of four veneer side slats, two on each side; three veneer top slats; three veneer bottom slats; four 15-gage binding wires; six veneer end slats, three on each end; and eight cleats, four on each end (fig. 1).

Polystyrene

The inside dimensions of the polystyrene box were 23¾ by 14 by 9¾ inches, and the outside dimensions were 25¾ by 16 by 11¼ inches. The tare weight of the box was approximately 1½ pounds.

The sides and ends were 1 inch thick, and the bottom and top were three-fourths of an inch thick. The cover fitted over a 3-inch-high necked-in flange molded in the main body of the container (fig. 2). The bottom of the box in the inside was designed so that melted ice water and drippings from the birds drained to the ends. Four triangular holes were molded at the junction of each side, end, and bottom panel. A handhole was located on each of the outside ends of the box.

Packing Operations

The wirebound boxes were received from the manufacturer preassembled, in knocked-down flat bundles. One man, using a hand tool, set up the boxes by opening them up and then bending two wire loops that interlocked around the cleats of the end panels. Another man inserted a paper parchment liner in the box. The boxes were then conveyed to the packing area.

The birds were graded, automatically sized by weight and dropped into bins, and then place-packed into the wirebound boxes. The number of birds per box varied according to the net weight of poultry packed. Generally, birds were packed two layers deep with two six-bird rows per layer, or a total of 24 birds per box.

After the boxes were filled, they were conveyed to

a scale and weighed. After allowances for average tare weight and shrinkage were made, labels noting net weight, count, and grade were stapled to one end of the wirebound box.

Twenty pounds or more of crushed ice was put into each box manually or by a semiautomatic icing machine. Then the boxes were conveyed to the closing area. In one plant the wirebound boxes were closed by an automatic machine, and in the other plant they were closed manually by interlocking four wire loops on the top lid with four wire loops on the front side of the box.

The processors received preassembled polystyrene boxes from the manufacturer. The boxes fitted all the equipment of the processors. No liners were needed; therefore, the boxes were placed directly on the conveyor in the storage area. The boxes were packed in the same manner as the wirebound boxes. The labels noting net weight, count, and grade were stapled to one end of the polystyrene box. A semiautomatic machine dumped 15 pounds of crushed ice into each polystyrene box.

After both the wirebound and polystyrene boxes were packed, the boxes were placed on pallets in one plant and on pushcarts in the other plant. The pallets and pushcarts were then taken to the loading dock, and the boxes were put one-at-a-time in the truck.

BN–16992

FIGURE 1.—Conventional wirebound wood-veneer box packed with poultry and ice. Note paper liner.

BN-32858

FIGURE 2.—Polystryene foam box packed with poultry and ice.

COSTS

Packaging Materials

The wirebound box including the parchment paper liner cost 51.5 cents per box. The polystyrene box was not available in commercial quantities; it is still in a stage of development. In view of this, no market price has been established for the box. The manufacturer estimates that the price of the polystyrene box delivered to the processing plant will be 55 cents per box. Labels, wing tags, and paper giblet wrappings were not included in the costs because these costs were independent of the type of box used.

Direct Labor for Packing

The direct labor requirements for packing a wirebound box and a polystyrene box were 1.66 and 1.35 man-minutes, respectively (table 1). Most of the difference was caused by the additional time for assembling the wirebound box and inserting a parchment paper liner. The polystyrene box was delivered to the receiver already assembled and did not require liners. The time for filling, weighing, labeling, and icing was the same for both types of boxes. The wirebound boxes were closed by an automatic closing machine in one processing plant, and manually in the other processing plant. The time for closing the wirebound box manually was 0.28 man-minutes. The time for closing the polystyrene box was 0.12 man-minutes. Stacking and loading the polystyrene boxes required 0.02 man-minutes more per box than the wirebound boxes, because the polystyrene boxes were carefully set in place to prevent damage to the box.

TABLE 1.—*Cost and amount of direct labor to pack and load poultry in wirebound and polystyrene boxes, by specific operations, 2 processing plants, Georgia and Alabama, 1967*[1]

Operation	Wirebound box		Polystyrene box	
	Labor	Cost	Labor	Cost
	Man-minute	*Cents*	*Man-minute*	*Cents*
Assembling	0.25	0.75	([2])	0
Inserting liner	.20	.58	([3])	0
Filling	.68	1.97	0.68	1.97
Weighing and labeling	.25	.72	.25	.72
Icing	.20	.58	.20	.58
Closing	([4])	0	.12	.35
Stacking and loading	.08	.23	.10	.29
Total	1.66	4.83	1.35	3.91

[1] Includes 15 percent allowance for fatigue and personal time. Average hourly wage was $1.75.
[2] Delivered to the processor ready for packing.
[3] No liners used.
[4] In one plant, boxes closed by automatic machine; no direct labor required. In other plant, manual closing required 0.28 man-minute.

Ice

The wirebound boxes used in this study were packed with 20 pounds of ice and the polystyrene boxes with 15 pounds. The cost of ice varied from one-fourth to one-half cent per pound depending on whether the processor used his water supply or the city's water supply. At one-fourth cent per pound, 20 pounds of ice packed in wirebound boxes and 15 pounds of ice packed in polystyrene boxes would cost 5.0 and 3.8 cents per box, respectively.

Transport

In most truck shipments of poultry, the trailers are not filled to full cubic capacity because of legal

TABLE 2.—*Costs of packaging materials, packing and loading labor, ice, and transport for wirebound and polystyrene boxes of poultry, 1967*

Item of cost	Wirebound box		Polystyrene box	
	Per box	Per 100 pounds of poultry	Per box	Per 100 pounds of poultry
	Cents	*Cents*	*Cents*	*Cents*
Box and materials	51.5	79.2	55.0	84.6
Packing and loading labor	4.8	7.4	3.9	6.0
Ice	5.0	7.7	3.8	5.8
Transport	40.8	62.8	36.7	56.5
Total	102.1	157.1	99.4	152.9

maximum weight restrictions. The gross weight of the polystyrene boxes packed with poultry is 9 pounds less—5 pounds of ice and 4 pounds of tare weight—than that of wirebound boxes of poultry. Based upon a legal load limit of 40,000 pounds per truckload, 490 polystyrene boxes containing 31,850 pounds of poultry or 441 wirebound boxes containing 28,665 pounds of poultry can be loaded in a typical truck shipment. Based upon the 1966 truck-operating costs of 36 cents per mile reported by the Farmer Cooperative Service[4] and 500 miles per average truck shipment[5] from processing plant to market, it would cost 62.8 cents to transport 100 pounds of poultry in wirebound boxes and 56.5 cents in polystyrene boxes.

Total Costs

The costs of packaging materials, packing and loading labor, ice, and transport per box and per hundredweight of poultry are shown in table 2. Although the polystyrene box costs 5.4 cents per hundredweight more than the wirebound box, there is a net saving of 4.2 cents per hundredweight to pack, load, and ship ice-packed poultry in polystyrene boxes rather than in wirebound boxes. A saving in cost of packing and loading labor, ice, and transport of 1.4, 1.9, and 6.3 cents, respectively, or a total saving of 9.6 cents per hundredweight more than offset the additional box cost. If 75 percent of the ice-packed poultry were shipped in polystyrene boxes, the annual saving would be approximately $2.2 million. This calculated annual saving would be greater if it were based on the 25 to 30 pounds of ice in wirebound boxes that many processors use instead of the 20 pounds of ice used in this study.

DAMAGE TO BOXES

Polystyrene boxes suffered more serious damage in transit than the wirebound boxes. The percentage of damaged wirebound and polystyrene boxes shipped in the six test shipments was as follows:

	Slight *Percent*	*Serious* *Percent*
Wirebound box	6.9	0
Polystyrene box	3.6	1.1

There were 482 wirebound boxes and 712 polystyrene boxes—the rest were fiberboard boxes—in the six shipments. Slight damage to the wirebound boxes consisted of broken slats on the top or sides of the boxes, or concave lids, or both. Slight damage to the polystyrene boxes consisted of chipped corners, cracked lids, bottoms, or sides, or both conditions. Seriously damaged polystyrene boxes were completely broken and could not be used to carry poultry in further distribution. In one shipment in which the boxes were loaded seven high, seven seriously damaged boxes were found on the bottom layer.

At four of the receivers' warehouses, both types of boxes were placed on pallets for storage. One receiver double-stacked four-layer pallet loads of polystyrene boxes without breakage. If the boxes were stacked more than four high on the pallet, the pallets could not be double-stacked because the polystyrene boxes might break. Wirebound boxes

[4] CAMP, T. H. MOTOR TRUCK OPERATING COSTS OF FARMER COOPERATIVES. U.S. Farmer Coop. Serv. Gen. Rpt. 121, 9 pp. June 1964.

[5] This trip length is fairly typical and is fairly close to average trip length reported in: SNITZLER, J. R., and BYRNE, R. J. INTERSTATE TRUCKING OF FRESH AND FROZEN POULTRY UNDER AGRICULTURAL EXEMPTION. U.S. Dept. Agr. Market. Res. Rpt. 224, 88 pp. 1958.

were generally stacked five high per pallet, and the pallets were often double-stacked without severe damage to the boxes.

At two of the receivers' warehouses, both types of boxes were unloaded with handtrucks and stacked six boxes high in storage rooms. The handtrucks often damaged the bottom polystyrene box in each stack. Wirebound boxes were also damaged (broken slats) by the handtrucks, but the wires binding the slats held the boxes together.

ICE LOSS AND TEMPERATURE

An analysis was conducted on the loss of ice. Percentages, rather than pounds, of ice melted were determined, because of the difference in the amount of ice put in the boxes at the time of packing. The average amount of ice lost in the six shipments was 50.3 percent for the wirebound boxes and 40.0 percent for the polystyrene boxes (table 3). The difference of 10.3 percent was not statistically significant because of the large variations among shipments. The polystyrene boxes retained a higher percentage of ice than the wirebound boxes when temperature in the truck was high (e.g., shipments 1, 4, 5, and 6). When refrigeration temperature was lower, there was little difference between the two box types (e.g., shipments 2 and 3).

The temperature of the air above the layer of ice inside the wirebound boxes fluctuated with the temperature of the air in the truck. Temperatures above the ice inside the polystyrene boxes were more uniform and lower than air temperatures in the wirebound boxes and air temperatures in the trucks. The highest percentage of ice lost in the wirebound boxes was 96.2 percent, and in the polystyrene boxes it was 68.3 percent. Both of these boxes were in the top layer of the truck. However, the temperature of the poultry below the layer of ice averaged the same for both types of boxes upon arrival at the receivers' warehouses. Some ice remained in all boxes.

TABLE 3.—*Percentage weight loss of ice in wirebound and polystyrene boxes, from processing plant to receiver's warehouse, 6 shipments of poultry, 1966-67*

[Means of the 6 boxes within each shipment]

Shipment No.	Time [1]	Average temperature of air inside truck	Weight loss of ice		
			Wirebound box	Polystyrene box	Difference
	Hours	*°F.*	*Percent*	*Percent*	*Percent*
1	18	42	57.8	41.0	—16.8
2	66	32	47.7	50.0	2.3
3	64	30	26.3	27.8	1.5
4	68	42	81.3	49.5	—31.8
5	18	39	27.7	23.5	—4.2
6	90	40	61.2	48.4	—12.8
Average [2]	..	..	50.3	40.0	..

[1] Hours between time of loading and unloading the boxes.
[2] Difference between averages was not statistically significant.

POULTRY SHRINKAGE

The average amount of poultry shrinkage in the six shipments was 4.5 percent in the wirebound boxes and 4.0 percent in the polystyrene boxes (table 4). This difference was not statistically significant because of the large variations among shipments.

TABLE 4.—*Percentage weight loss of poultry carcasses in wirebound and polystyrene boxes, from processing plant to receiver's warehouse, 6 shipments, 1966-67*

[Means of the 6 boxes within each shipment]

Shipment No.	Time [1]	Average temperature of air inside truck	Weight loss of poultry		
			Wirebound box	Polystyrene box	Difference
	Hours	*°F.*	*Percent*	*Percent*	*Percent*
1	18	42	3.6	2.3	—1.3
2	66	32	5.0	5.0	0
3	64	30	5.3	4.1	—1.2
4	68	42	4.1	4.5	.4
5	18	39	5.6	4.8	— .8
6	90	40	3.6	3.2	— .4
Average [2]	..	..	4.5	4.0	..

[1] Hours between time of loading and unloading the boxes.
[2] Difference between averages was not statistically significant.

TRADE REACTION

The six receivers preferred the appearance of the polystyrene boxes. All the receivers said that the polystyrene boxes appeared more sanitary, since drainage from boxes stacked above could not leak into the lower boxes. Two receivers stated that there was more ice in the polystyrene boxes. In these two shipments (Nos. 4 and 6), the air temperature

inside the trucks averaged 40° and 42° F. All the retail butchers said that the polystyrene box was easier to handle, to open, and to empty than the wirebound box. The polystyrene box was easier to empty because the box could be turned upside down and the bottom removed. The birds could then be removed without reaching through the ice.

The receivers reported that the greatest advantage of wirebound boxes was their strength. All the receivers said that the polystyrene boxes had to be handled carefully. The boxes could not be thrown onto pallets or in and out of trucks. Palletized handling of polystyrene boxes was not so satisfactory as of wirebound boxes. Pallets of polystyrene boxes with more than four layers per pallet could not be double-stacked.

DISCUSSION

Requirements for shipping containers for ice-packed poultry are many and difficult to meet. The box must be able to hold 80 to 100 pounds of poultry and ice. It must support an overhead weight of 800 to 1,000 pounds when double-stacked on pallets with five or six layers per pallet. It should keep the contents clean by preventing the entrance of foreign material, and it yet must provide a method of draining ice water and body fluids from within. It must be impervious to damage or softening by long periods of direct contact with fluids. It must be easy to store, to assemble, to pack, and to handle. It must also meet the needs of the retail butcher, who wants a sanitary, attractive box that is easy to open and empty. It should prevent ice from melting during periods of nonrefrigeration.

The outstanding virtue of the wirebound box is its rugged construction. It can be thrown in and out of trucks or onto pallets without damage other than broken slats. It withstands overhead weight of 1,000 pounds or more with little damage, except concave lids. Constant exposure to liquids results in no adverse effect. A disadvantage is its inability to prevent the entrance of foreign materials or drainage from overhead. Warehouse receivers and retail butchers are divided in their opinions as to the ease of handling and disposal of the wirebound box.

The polystyrene box prevents drainage from overhead and entrance of foreign materials. It is easy to handle, to open, and to empty. Constant exposure to moisture results in no adverse effects. A disadvantage is the box's inability to withstand extreme shocks. Another weakness of the polystyrene box used in this study is that it cannot withstand overhead weight of more than 700 pounds. It is possible to develop a polystyrene box that can withstand overhead weight of 1,000 pounds or more. But, whether it can be done at a cost permitting the boxes to be delivered to the poultry processor for the price of the box used in this study is unknown. It is believed that the polystyrene boxes used in this study probably will not have general trade acceptance, unless they are made sturdier.

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