Investigations on Long Distance Transportation of Fish: IV. A Comparative Study of the Performance of Expanded Polystyrene Slabs and Multi-layer Gunny (Jute) Fabric as Insulants

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A comparative study of the insulation efficiencies of expanded polystyrene slabs and multi-layer gunny fabric in long distance transportation of fresh iced fish was made. Used plywood boxes (second hand teachests) were employed as containers and the experiments conducted between Kakinada and Calcutta. All the three insulants tried, namely, 25.4 mm thick expanded polystyrene slab, four and two layer gunny (jute) fabric, all sealed in 150 gauge polythene sheets, showed comparable insulation efficiencies, considering total bacterial counts, organoleptic qualities and TMA and TVN values of the transported fish as parameters.

The earlier communications in this series dealt with studies on transportation of frozen fish from Cochin to Calcutta in expanded polystyrene insulated plywood boxes by ordinary rail wagons (Govindan *et al.*, 1977), design and fabrication of an insulated, dismantable and returnable galvanised iron container for long distance transportation of iced and frozen fish (Govindan & Gupta, 1978) and field trials conducted for exploring and establishing the efficiency of this container (Govindan *et al.*, 1978). Results obtained in the first of these reports as well as those reported by Venkataraman *et al.* (1976) have established the efficiency of expanded polystyrene slabs as an insulation material for long distance transportation of fresh iced and frozen fish. However, the high cost of this material and its brittle nature pose as two of the most important deterrants in and weigh heavily against its wide commercial application. Multi-layer gunny (jute) fabric, while devoid of the above two draw backs, possesses good insulation property, which facilitates its use for the above purpose. In the present study, an attempt is made to carry out a comparative evaluation of the insulation efficiencies of 25.4 mm thick expanded polystyrene slabs and two and four layer gunny (jute) fabric, all sealed in 150 gauge polythene sheet in experimental transportation of fresh iced fish from Kakinada to Calcutta, employing chemical, physical and organoleptic alterations occurring in the transported fish as criteria for evaluation.

Materials and Methods

Expanded polystyrene slab (1 m x 0.5 m x 25.4 mm) and 150 gauge polythene sheet supplied by standard manufacturers and jute fabric and second hand teachests as available in the local markets were employed in this study. Bulk density (kg/m^3) and thermal conductivity (kcal/h/m^2/unit temperature gradient) of the insulation and container materials were determined as described by Chattopadhyay *et al.* (1974). Expanded polystyrene slabs were cut to the size of the

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plywood container. Gunny fabric was also cut to size and double and quadruple layers of the same stitched together along the borders. All the three were heat sealed in 150 gauge (0.038 mm thick) polythene film and placed at the bottom and sides of the container, which was then filled with ice and fish in 1:1 proportion in alternate layers, bottom and top layers being ice. The top layer of insulation was then placed in position and the lid of the box nailed on. The container was then given an outer wrapping with single layer gunny fabric and stitched securely. A binding with coir rope was provided above the gunny wrapping as an additional measure of protection and to facilitate handling during loading and unloading.

Three different sizes of second hand tea-chests, namely, 36 cm x 49 cm x 36 cm (35 kg capacity), 47 cm x 50 cm x 38 cm (50 kg capacity) and 56 cm x 44 cm x 35 cm (60 kg capacity) as available in the local market were employed in these studies. Fishes used were mainly marine and consisted of sciaenids, saurida, synagris, cat fish, horse mackerel, psenus, ribbon fish, polynemus, pomfret, eel, sardine hilsa, shark, tuna and caranx. Brackish water fish like chanos and fresh water varieties like rohu and tilapia were also utilised to a lesser extent. Altogether seven metric tonnes of fish were transported in these studies in 124 consignments employing the three insulations. The experiments were spread over a period of two years, from October 1975 to September 1977. The consignments were booked at Kakinada Port Railway Station and transported to Calcutta in ordinary (uninsulated) rail wagons, involving one transhipment at Samalkot Junction, the normal duration of journey being 40 h at ambient temperatures of 25 to 35°C. The fishes were received at Calcutta and disposed off through M/s Central Fisheries Corporation, after drawing samples for determination of quality.

Total bacterial and coliform counts were determined as described by Govindan *et al.* (1978) and TMA and TVN by Conway's microdiffusion method (1947). Statistical analysis of the data was carried out by standard methods.

Results and Discussion

The physical properties of the insulation and container materials used in these studies are reported in Table 1.

Table 1. *Physical properties of the insulation and container materials*

Material	Thickness mm	Bulk density kg/m³	Thermal conductivity kcal/h/m³/°C/m
Polythene sheet	0.038	940	0.026
Expanded polystyrene	25.40	15	0.028
Polythene—2 layer gunny fabric—polythene	2.50	500	0.046
Polythene-4 layer gunny fabric—polythene	4.50	580	0.039
Plywood	4.00	480	0.037

Total bacterial counts at the transporting and receiving ends were compared with a veiw to study the changes in the quality of the fish as reflected by this criterion. Calculations were made after necessary logarithmic transformations. The average (log) values at both centres for different species were calculated and the analysis of variance technique was applied to examine whether the changes in total bacterial counts are significant at the receiving end. The results are presented in Table 2.

It is seen from the table that changes in total bacterial counts between centres are highly significant ($P<0.01$), while those bet-

Table 2. *Anova of total bacterial counts*

Source	S. S.	D. F.	M. S.	F
Between centres	2.1675	1	2.1675	16.78
Between species	2.3972	16	0.1498	1.16
Error	2.0675	16	0.1292	
Total	6.6322	33		

Table 3. *Changes in total bacterial counts (log values) species-wise and insulation-wise*

Variety of fish	Expanded polystyrene		Quadruple layer gunny		Double layer gunny	
	Kakinada	Calcutta	Kakinada	Calcutta	Kakinada	Calcutta
Sciaenids	4.7261	4.5407	4.8289	4.5523	4.5944	4.6696
	(— 3.9)		(— 5.7)		(+ 1.7)	
Hilsa keeli	4.5870	4.4312	—	—	—	—
	(— 3.4)					
Synagris	4.8563	4.7373	4.6495	5.0912	4.6223	4.5182
	(— 2.5)		(+ 9.5)		(— 2.3)	
Tilapia	4.4046	4.3217	—	—	—	—
	(— 1.9)					
Cat fish	4.3699	4.6723	4.6228	5.0536	4.3372	5.0107
	(+ 6.9)		(+ 9.3)		(+15.5)	
Chanos	4.2392	4.6101	4.1618	4.6591	4.7260	5.1095
	(+ 8.8)		(+11.9)		(+ 8.2)	
Rohu	4.4145	5.0885	—	—	—	—
	(+15.3)					
Polynemus	3.7258	4.4529	4.6335	5.3979	4.4644	5.1523
	(+19.5)		(+16.5)		(+15.4)	
Eels	4.1500	4.9771	—	—	—	—
	(+19.9)					
Pomfret	3.6655	4.9204	—	—	—	—
	(+34.2)					
Horse mackerel	—	—	—	—	4.600	5.3377
					(+ 6.1)	

ween species (both centres taken together) are not significant. This may be due to the fact that some of the species registering highest increases at the receiving end have only low total bacterial counts at the transporting centre, thus the values at both the centres getting evened out among the different species.

The mean values of total counts (log values) at both Kakinada and Calcutta for each species and for different insulations are presented in Table 3. The increase/decrease in total counts are given in parenthesis as percentages. It may be seen from the table that the rates of changes in the total bacterial counts vary very much from species to species, but they are influenced to a very little extent only, by the different insulants.

The effects of the three insulations used were also examined by pooling together the changes in total bacterial counts for different species and for each type of insulation material. Though the mean values showed that the increases were least in 25.4 mm thick expanded polystyrene, followed by quadruple and double layer gunny fabric in the order, application of the t-test proved that no appreciable differences exist among the three insulations, value of t being non-significant in all cases.

Organoleptic ratings were also analysed to compare the insulation efficiencies of the three insulants. All consignments were in 'good' condition while despatching from the transporting centre. At the receiving end, more than 80% of the consignments reached in 'fair' condition while the rest were in 'good' and 'poor' conditions. For each insulation, the organoleptic data at the receiving end were classified into 'good' 'fair' and 'poor' categories, forming a 3 x 3 contigency table. Chi-square test was applied. The value of chi-square was found to be non-significant at 5% level, calculated chi-square being 1.78.

Table 4. *Mean TMAN and TVN values for each species at the despatching and receiving centres*

Species	TMAN (mg/100g)		TVN (mg/100g)	
	Kakinada	Calcutta	Kakinada	Calcutta
Sciaenids	2.41	6.88	10.83	17.60
Synagris	1.67	6.64	15.27	18.18
Cat fish	1.39	6.19	19.71	16.89
Chanos	2.73	5.78	15.08	17.46
Saurida	0.97	7.15	12.72	21.04
Hilsa	3.13	13.05	15.83	17.73
Ribbon fish	3.27	9.45	12.39	17.45
Tilapia	..	..	20.56	24.96
Pomfret	1.82	8.03	13.81	28.72
Eel	2.02	8.08	8.70	14.61
Polynemus	0.54	9.78	9.61	17.86

Therefore it could be inferred that the two characters under study, namely, the organoleptic ratings at the receiving end and the insulations were independent. No significant differences existed among the three insulation materials studied as regards their insulation efficiencies, their performances being equally efficient in long distance transportation of fresh iced fish.

The mean values of TMAN and TVN for each species are presented in Table 4. Both values were found to increase rapidly at the receiving end. Since all the three insulants studied behaved similarly in their efficiencies, these indices have been examined species-wise only. However, if insulants possessing a different level of insulation efficiency are employed, changes in these indices also would be different from the present pattern.

It may be of interest to note that at the despatching centre, only 3.3% of the samples showed coliform counts of above 1000/g, while 36.7% had only less than 100 of this organism/g and the remaining samples were completely free from them. These micro-organisms were reduced to nil or negligible numbers at the receiving centre due to the dual effects of leaching out by the ice melt water and destruction by the low temperature during transportation. Lekshmi (1964) has shown that these organisms are sensitive to cold.

Thermal conductivity of expanded polystyrene recorded in literature is 0.027 to 0.031 kcal/h/m²/°C/m (FAO, 1960), which is in full agreement with the present value. These values in the case of the three insulants under comparison show a gradation. Still all of them are sufficiently low in thermal conductivity and this fact explains their comparability in performance also.

Gunny fabric has a definite advantage over polystyrene in that it costs only one-third or one-sixth of the latter for quadruple and double layer insulations respectively, the cost of the latter for a 60 kg capacity tea-chest being Rs. 27.50. A second advantage of the former is that it is not brittle. In both cases, the insulations as well as the containers have to be promptly taken out, cleaned and dried at the receiving end so as to ensure maximum degree of reusability. The greatest disadvantage of the gunny fabric is that when once the polythene film encasing it gets punctured, say, by the spines of the fish or any rough or pointed material, the ice melt water enters and readily soaks the insulant, adversely affecting its thermal efficiency. Expanded polystyrene on the other hand, absorbs only very small quantities of mois-

ture even in contact with ice melt water, as it is not altogether proof to moisture. While this insulant is rigid and stays in position even after the bulk in the container gets reduced due to meltage of ice, gunny fabric tends to sag in under such circumstances due to its flexible nature. Thermal conductivity of the container material (plywood) is also sufficiently low (0.037). However, that too has the disadvantage of absorbing moisture from the ice melt water at the cost of thermal efficiency and its own strength. On the whole, for cheap and efficient transportation of fresh iced fish over long distances, this combination of second hand plywood box and multi-layer gunny fabric holds out promising prospects.

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