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Designing and testing of low cost cooling devices for storage of vegetables in summer

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ABSTRACT

Based on the principle of evaporative cooling five low cost cooling devices were designed using low cost and easily available materials which could be utilized by the rural masses and economically backward class. Five different models of 40 cm x 40 cm x 60 cm size and the storage capacity of 96 liters were made. The vegetables selected for storage in the devices were lady's finger, cluster beans, spinach, each 350 gms and coriander leaves 50 gms. The experiment was carried out for subsequent seven day during summer season. The other observation regarding temperature, relative humidity and physiological characteristics of the stored vegetables were assessed by the selected panel members using score card by applying 5 point scale. Average temperature drop inside the devices was to the extent of 10°C to 12°C than that of room temperature. The lowest minimum temperature was noted in B model. Maximum relative humidity was high in all models, higher being in B model. Ranging from 81% to 91%. Average physiological weight losses were observed minimum in B model in all vegetables on third day the losses were 1.42 to 10 per cent in spinach. Moisture losses were observed in model A.E. and minimum in model B in all selected vegetables. Average vitamin 'C' losses were maximum in model E followed by A comparatively per cent losses were minimum in B, C, D, model. Physical characteristics maximum score of color, texture, aroma and overall freshness in model B. Based on the ranking of mean score B model (Exterior materials gunny bag with coal) secured first rank for all the characteristics. Indicating best performance in the storage of selected vegetables in peak summer. Statistical analysis proved highly significant different in all the models.

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Vegetables are one of the important groups of balanced diet. They are rich sources of many nutrients such as calcium, iron, carotene, and vitamin 'C' which are essential for growth and maintenance of normal health. Vegetables are highly perishable in nature and soon after their harvest, they start loosing their freshness. Shriveling of fresh vegetables owing to high temperature and low humidity is a feature commonly observed particularly in northern part of the country during summer (Roy and Khuridiya1982). Central Village Pottery institute Kanpur (U.P.) had developed a cheap fridge better known as Janata refrigerator (Grameen Sheetak) (Anonymous 1979). It is made up of clay and was very inexpensive. It was suggested to facilitate storage of fruits, vegetables milk, egg etc.

(Roy and Khuridya, 1986) A low cost cooling chamber developed and studied that the inside temperature of cool chamber was reduced from 43°C out side temperature to 23°C while relative humidity increased from 33 to 95 per cent during peak summer. In these chambers, the shelf life of leafy vegetables was increased 3 days to 6 days when kept outside. Maini *et al*. (1984) found that physiological weight loss for potatoes in the desert cooling system at 24.28°C temp and 90% relative humidity was half as much as at ambient temperature of 36.41°C. After storage of five weeks a loss of 3.3 per cent was observed in cool storage compared with 18.6 per cent at room temperature and 9.3 per cent in the desert cooled storage. Taking all above points into consideration there are numerous problems in vegetable storage of rural masses. The main constraints lie with availability of vegetables in weekly market. The storage of vegetables is very difficult in summer season. Based on the principle of evaporative cooling five low cost cooling devices were designed using low cost and easily available materials which could be utilized by the rural masses and economically backward class at College of Home Science M.A.U., Parbhani. The present investigation was carried out to - Design and fabrication of low cost cooling devices, to test these cooling devices for vegetable storage- temperature and humidity, weight losses, physiological characteristics and moisture content, Vitamin'C' content and to identify best cooling device among those selected.

METHODOLOGY

Development of cooling devices:

Based on the principles of evaporative cooling, five different models of 40 cm x 40 cm x 60 cm size having the storage capacity of 96 liters were made. The complete device comprised of three different part such as-basic bamboo structure, water holding trays and exterior materials covering basic frames.

The water holding trays were placed on the top of basic frame for storing water to allow continuous dripping. The exterior material model A gunny cloth, model B gunny bag filled with charcoal ½ kg,model C khus covering 2 cm thick,Model D gunny bag filled with spognum moss model E desert bag cloth (2mm thick). Four inch thick sand layer was spread underneath the frame to get cooling effect from the floor level.

Selection of vegetables:

Vegetables which were commonly consumed and locally available, particularly in summer were selected. These included two common vegetables, such as lady's finger (*Abelmoschus esculentus*), cluster beans (*Cyamopsis tetragonoloba*) and two leafy vegetables such as spinach (*Spinacia oleracea*) and coriander leaves (*Coriandrum sativa*).

Recording the temperature and humidity:

The temperature were noted for each model using (wet bulb and dry bulb) thermometers at every two hours from 7:30 A.M. to 7:00 P.M. besides room temperature. Humidity was also measured after every two hours inside the models and room, using hygrometer (range 0 to 100%).

Physical characteristics of the vegetables:

Development of score card:

A score card was developed using five point scales as recommended by Swami Nathan (1979) to assess the physical characteristics of stored vegetables. The parameter for the evaluation included color, texture, aroma and overall freshness.

Recording weight loss in selected vegetables:

The initial weight of the vegetables was noted, rechecked and cleaned by discarding the spoiled ones and reweighed daily to know the weight loss by top pan balance.

Percentage of moisture content in the selected vegetables:

Percentage of moisture content in the vegetables was determined daily by air oven method.

Vitamin C content in selected vegetables:

Ascorbic acid content of vegetables was estimated by 2.6 dichloro-indophenol method.

Identifying best cooling device among those selected:

All the selected characteristics of the stored vegetables were ranked on the basis of their performance indicated by mean score to find out the most effective cooling devices.

Statistical procedure:

The statistical analysis of the data was carried out by applying Factorial Randomized Block Design as per (Snedecor and Cocharn, 1967).

Ranking:

Means scores obtained for the given characteristics of selected vegetables and stored in the selected model during experimental period were ranked.

RESULTS AND DISCUSSION

Temperature and humidity inside and outside the models:

It is stated that average room temperature ranged between 34.28 to 36°C during seven days experiment. The average minimum and maximum temperature in the models were observed 22.85 to 24.20 in model B and 26 to 27.5 in model E respectively. Average temperature drop inside the devices was to the extent of 10°C to 12°C than that room temperature. The lowest minimum temperature was noted in B model Relative humidity in the room ranged between 23 to 30 per cent. Maximum relative humidity was high in all models higher being in the B model ranging from 81% to 90%. Results are highly significant for the room temperature and humidity with respective models A, B, C, D and E.

The ranking of the mean scores of selected characteristics of spinach, coriander leaves, lady's finger and cluster beans when stored in the selected models and room during experiment period have been recorded in Table 1and 2

Table 1 indicated ranking of the mean scores for the selected characteristics in the storage of the spinach for five days. As seen the storage in room control sample of spinach became unmarketable in less than a day while the sample kept in selected models remained fresh up to three days. Average physiological weight losses were observed minimum in B model in all vegetables on third day the losses were 1.42 to 10 per cent in spinach. According to ranking, B model had scored lowest and hence secured first rank for all the characteristics while

Table 1 : Ranking of the means score of the selected characteristics of spinach and coriander leaves when stored in the room and room and selected models during experimental period

Models & Room		Temperature Celsius	Humidity Percentages	Physiological characteristics				Physiological weight (kg)	Moisture content percentage	Vitamin C content Mg	Total mean score	Rank
				Colour	Aroma	Texture	Overall freshness					
Room	S	36(VI)	23(VI)	1(VI)	1(VI)	-	1(VI)	80	35	10.0	5.00	VI***
	C			1(VI)	1(VI)	-	-	10(VI)	40(VI)	35.00(V)	5.00	
A	S	25.10(III)	80.42(IV)	4.06(IV)	4.08(III)	3.97(IV)	3.72(III)	196.38(IV)	90.00(IV)	21.66(IV)	3.88	IV**
	C			4.77	4.66(IV	4.03(V)	4.63 (IV)	28.97 (IV)	84.40(V)	97.66(IV)	4.11	
B	S	22.85 (I)	87.57 (I)	4.83 (I)	4.55 (I)	4.66 (I)	4.50 (I)	242.77(I)	91.46(I)	24.33(I)	1	I*
	C			4.88(I)	4.84(I)	4.55(I)	4.85 (I)	35.83 (I)	85.86(I)	106(I)	1	
C	S	24.23 (II)	84.28(III)	4.82(II)	4.45(III)	4.50(II)	4.37(II)	228.33(II)	90.60(III)	24.00(II)	2.22	II
	C			4.86(II)	4.71(II)	4.40(II)	4.76(II)	32.11(III)	85.26(II)	104.33(III)	2.11	
D	S	24.23 (II)	84.42 (II)	4.38(III)	4.48(II)	4.56(II)	4.37(II)	210.44(IV)	90.80(II)	23.66(III)	2.55	III***
	C			4.80(III)	4.69(III)	4.34(II)	4.75(III)	313.44(III)	85.17(III)	98.66(III)	2.77	
E	S	26.00 (IV)	76.57 (V)	3.9(V)	3.84(V)	3.63(V)	3.30(V)	32.77(II)	89.28(V)	20.00(V)	4	V
	C			4.28(V)	4.57(V)	4.13(IV)	4.63(IV)	26.58(V)	84.80(IV)	97.5(V)	4.55	V
F	S	94.29**	19.86	3.83***	1.24^{NS}	6.82**	2.21**	11.81**	8.24**	10.2**		
value	C			9.26.29	2.34	7.41	6.40	11.96	9.8	4.5		

Ranks are denoted in parenthesis S = Spinach C = Coriander leaves

C and D scored second and third rank, respectively for almost all the characteristics. The total rank score was lowest for model B followed by C, D and E.

Coriander:

As evident in the Table 1 the control samples of coriander leaves become un marketable in less than a day while the samples kept in different models remained fresh up to three days for all characteristics. At the end of three days storage the physiological losses in weight (PLW) losses primarily owing to transpiration and respiration was found 80 per cent in case of control sample. Where as in the cooling devices the P.L.W. in coriander varied from 20 to 48. Model B had scored first rank for all the characteristics consistently. While model C, D had secured second and third position respectively for almost all the characteristics of coriander leaves. Model A and E had secured fourth and fifth rank respectively. Based on total ranking score the model B claimed first rank confirming its superior performance.

Table 2 : Ranking of the means core of the selected characteristics of ladies finger and cluster beans when stored in the room and room and selected models during experimental period

Models & Room		Temperature Celsius	Humidity Percentages	Physiological characteristics				Physiological weight (kg)	Moisture content percentage	Vitamin C content Mg	Total mean score	Rank
				Colour	Aroma	Texture	Overall freshness					
Room	L	36(VI)	23(VI)	2(IV)	2.3(IV)	2 (IV)	1.5 (IV)	150	50.14	4.9	6	VI***
	C			2.3	2.5	2.1	2.00	165	48.15	12.67	6	
A	L	25.10(I)	80.42(I)	4.76(V)	4.85(III)	4.77(IV)	4.81(II)	317.33	86.54	8.66	4	IV**
	C			4.84	4.87	4.76	4.77 (IV)	312.04 (III)	78.33(III)	36.83 (IV)		
B	L	23.65 (I)	87.57 (I)	4.91 (I)	4.99 (I)	4.88 (I)	4.88 (I)	333.90(I)	88.40(I)	11.06(I)	1	I*
	C			4.93(I)	4.96(I)	4.90(I)	4.90 (I)	329.52 (I)	79.72(I)	39.66(I)		
C	L	24.23 (II)	84.28(III)	4.83(III)	4.90(II)	4.81(II)	4.81(II)	324.19(II)	87.34(III)	9.88 (II)	2.22	II
	C			487	4.92	4.81	4.82	318.09	79.14	37.5	2.22	
D	L	24.23 (II)	84.42 (II)	4.85(II)	4.90(II)	4.78(III)	4.77(III)	321.71(III)	87.39(II)	9.5(III)	2.55	III
	C			4.85(III)	4.88(III)	4.8(II)	4.82(II)	318.38(II)	78.23(IV)	38.33(II)		
E	L	26.63 (IV)	76.57 (V)	4.75(IV)	4.80(IV	4.70(V)	4.74(IV)	304.61(V)	86.14(V)	8.00(V)	4.55	V
	C			4.77(V)	4.80(V)	4.70(IV)	4.76(III)	311.42(V)	71.15(V)	33.66(V)		V
F	L	94.29**	69.86	5.647***	8.582**	3.415**	3.60**	6.09**	18.58**	10.22**		
value	C			9.66**	9.76**	5.73**	1.36^{NS}	2.34^{NS}	5.79**	4.5**		

Ranks are denoted in parenthesis L = Ladies Finger C = Cluster beans

Lady's finger:

Ranks of mean score for the selected characteristics studied for ladies finger are recorded in Table 2. As evident ladies finger become unmarketable within 2 days when stored at room temperature, while they remained marketable unto 7 days when kept in cooling devices. The physiological losses in weight of ladies finger kept in cooling devices and at room temperature up to 7 days varied from 5 to 13 per cent and 58 per cent respectively. As evident model B scored lowest mean score and hence the first rank for all the selected characteristics. While C and D had obtained second and third rank for most of the characteristics. Based on the total ranking score, model B topped the list and C, D were next to the order of superiority.

Cluster bean:

Table 2 also indicates the rank mean score of selected characteristics in the storage of cluster beans which was found to be more or less same in all the models. The control sample of cluster bean became unmarketable in less than two days. While the sample kept in the cooling devices remained fresh up to 7 days.

At the end of seven days storage, physiological losses in weight was found to be 55 per cent in cluster bean in case of room control samples whereas in the cooling devices the PLW in cluster bean varied from 6 to 12 per cent only for the same storage period.

At noted, B model had obtained first rank for all the characteristics while C and D had second and third rank for most of the characteristics. The total rank score confirmed first rank of model B projecting it as the best model followed by C and D as second third score respectively.

Conclusion:

Average temperature drop inside the devices was to the extent of 10^0C to 12^0C than that of room temperature. Lowest minimum temperature was noted in model V. Maximum relative humidity was high in all modes, higher in B model ranging from 81% to 91% in summer. Average physiological weight losses were observed minimum in B model in all vegetables.

Based on the ranking of mean score, B model secured first rank for all the characteristics indicating best performance in the storage of selected vegetables in peak summer.

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