Plant Archives Vol. 14 No. 1, 2014 pp. 507-510 ***ISSN 0972-5210***

DETERMINATION OF SOME PHYSICAL PROPERTIES OF INSULATION MATERIALS AND FOR SELECTED VEGETABLES TO DESIGN A LOW COST EVAPORATIVE COOLING SYSTEM

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Abstract

In order to develop a low cost cooling system with the objective to know the best insulation material, which has good water holding capacity that suits for low cost evaporative cooling system, some physical and rheological properties of industrial coir pith, fine charcoal and different side covering materials were determined. The bulk density, true density and porosity of coir pith and charcoal were found to be 58-60 kg/m^3 and 82-90 kg/m^3 respectively, 95-98 kg/m^3 and 208-220 kg/m^3 respectively, 38-41 and 59-63%, respectively. The water holding capacity of different side covering and packing materials were determined by soaking in water for 4-6 hours the materials used are *viz*., onion bagging cloth, single layer gunny cloth, double layer gunny cloth, felt cloth, coir pith, charcoal was found to be 52.4-54.6, 50.3-53.5, 68.2-70.4, 28.1-31.2, 60.2-63.3, 69.1-72.3% respectively. The highest water holding capacity was found to be in charcoal, this material was used as a packing material such that this will increase the relative humidity in a confined space and thus reduces the respiration and transpiration rate of the produce and the product remains fresh.

Key words : Agricultural wastes, water holding capacity, charcoal, coir pith, bulk density.

Introduction

Many developing countries are keen in utilizing agricultural residues, agricultural wastes and other materials for the useful purpose as it is possible to produce energy and to develop clean environment with low cost (Parr *et al*., 1992). The agricultural residues, which are locally available in considerable quantity can be effectively used for various purposes. Some of the major agricultural residues and other materials were like coir pith, wood shave, cotton stalks, ground shells, charcoal and gunny cloth. The physical and rheological properties of these packing and side covering materials were important while designing the low cost cooling system. The materials, which were used as a packing and side covering material should have good water holding capacity. Water holding capacity is the major factor while selecting any insulation material, such that it reduce temperature and increase the relative humidity in a confined space. However, the respiration and transpiration of the vegetables can be controlled with out damaging the produce.

The industrial coir pith were compressed and filled at the sides of the walls of the evaporative cooling structure such that the coir pith absorbs water, it increases size after absorbing water to its third of the original size. The pores of the coir pith expand such that bulk density increases before absorbing the water. The coir pith are compacted to a particular size, water is poured on the pith sponge during exporting of the agricultural products it retains the eater for more time because of the density of the pores increases so coir pith absorbs more water nearly 40-60% (Krishnamurthy *et al*., 2009) so, this material was used as an insulation material.

The effect of local charcoal from Ghana. Three types of charcoal were applied in spherical containers of 5, 10 and 15 kg capacity fill water into it. Results indicated that WHC was increased when charcoal was applied at all rates compared to zero application. However, there was not much difference in effect on WHC between the

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rates (Dugana, 2010). It is suggested that water adsorbent of the charcoal partly explains this behaviour. Improving WHC by sandy textured soils and the WHC capacity was 45-72% with porosity having 45-69%.

The objective of this study was to determine physical properties of the coir pith and charcoal namely bulk density, true density, porosity, water holding capacity when soaked. It was necessary to know physical properties of coir pith and charcoal for design and development of low cost evaporative cooling system. Methods and procedures for determining most physical and mechanical properties of agricultural products have been described by Mohsenin (1986).

Materials and Methods

Sample preparation

The industrial coir pith and fine charcoal were procured from the local market at Bangalore for determining the physical properties of the coir pith and charcoal. The coir pith was compressed, make it a small bulb like structure around 4-5cm and the charcoal was cutted into pieces of average length of 2-3cm. The standard procedures suggested by Mohsenin (1986) have been followed. The details of the properties determined and the methods followed are described below.

Physical and rheological properties

Bulk density

A perfect rectangular wooden box was taken and its volume was determined by multiplying length with width and height (l × b × h) and then the box was completely filled with the sample. The weight of the sample required to fill the box was recorded and the bulk density was determined using the following relationship.

$$\text{Bulk density (kg/m}^3) = \frac{\text{Weight of sample in container (kg)}}{\text{Volume of wooden box (m}^3)}$$

True volume

The volume of charcoal, coir pith used for evaporative cooling was determined by simple technique of toluene displacement method. The sample was first weighed on the scale in air and then dipped into toluene by means of a sinker rod. The second reading of the scale with the sample submerged minus the weight of the container and toluene is the weight of displaced toluene, which was used in the following expression to calculate the volume:

$$\text{True volume of sample (m}^3) = \frac{\text{Weight of displaced toulene}}{\text{Weight density of toulene (m}^3)}$$

True density

Knowing the weight in air and the volume, the true density of the sample was then obtained by the ratio of weight of volume (Mohsenin, 1986).

$$\text{True density (kg/m}^3) = \frac{\text{Weight (kg)}}{\text{Volume (m}^3)}$$

Moisture content

The moisture content of gunny bag, charcoal and coir pith was calculated on wet basis as,

$$\text{Moisture content} = \frac{W_m}{W_m + W_d} \times 100$$

Where,

W_m = Weight of moisture and

W_d = Weight of dry matter

Porosity

The porosity is also known as the packing factor and it was determined from bulk density and true density of coir pith and charcoal using the following expression.

$$\text{Porosity (\%)} = \frac{\text{True density} - \text{Bulk density}}{\text{True density}} \times 100$$

Physiological loss in weight (PLW %)

The PLW was measured to know the per cent weight loss of the selected vegetables and the weight loss was kept as standard 10% then it was considered as end of the shelf life.

$$\text{Physiological loss in weight} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Water holding capacity of different side covering material of EC chamber

Samples of jute bag generally used for onion bagging, single layer gunny cloth, double layer gunny cloth and felt cloths, coir pith and charcoal were taken and noted down the initial weight then, dipped the samples in a bucket containing water for 6 hrs. Final weight was noted to calculate moisture holding capacities of different samples. This procedure was used to calculate the water holding capacity of different materials and the equation used are as follows.

$$\text{Water holding capacity (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}}$$

Results and Discussion

Physical and rheological properties

For determination of physical and rheological properties of coir pith and charcoal, coir pith was compressed make it round and charcoal cutted into pieces of 2-3 cm.

Bulk density

The mean bulk density of selected vegetables are presented in table 1 and also the mean bulk density of coir pith and charcoal of required size was found to be 58 and 85.66 kg/m^3 is presented in table 2.

Table 1 : Bulk density of selected vegetables.

S. no.	Vegetables	Bulk density (kg/m^3)
1.	Beans	285.05
2.	Carrot	566.02
3.	Okra	296.15
4.	Tomato	575.64
5.	Leafy vegetables	179.48

The bulk density of the selected vegetables were determined as these properties are important to know the capacity of the evaporative cooling system.

True density

The mean true density of coir pith and charcoal was found to be 96 and 217.66 kg/m^3 presented table 2.

Table 2 : Bulk density, true density and porosity of coir pith and charcoal.

S. no.	Sample	Bulk density (kg/m^3)	True density (kg/m^3)	Porosity (%)
1.	**Industrial coir pith**	60	98	39
		56	95	41
		58	95	38
	Mean	58	96	39.33
2.	**Fine charcoal**	85	208	59
		90	225	60
		82	220	63
	Mean	85.66	217.66	60.66

Porosity

The mean porosity of coir pith and charcoal was found to be 39.33 and 60.66%, respectively was presented table 2.

The physical properties of coir pith and charcoal were studied, as these properties were necessary to design and develop the low cost evaporative cooling system. It was observed that the mean bulk density for coir pith and charcoal were 58 and 85.66 kg/m^3. The mean true density of coir pith and charcoal were 96 and 217.66 kg/m^3. The mean porosity of coir pith and charcoal 39.33 and 60.66% respectively.

Water holding capacity (WHC) of different covering and packing material

The values of WHC of different samples like onion bagging cloth, single layer gunny, double layer gunny, felt cloth, coir pith an charcoal are presented (table 3).

Table 3 : Water holding capacity of different materials.

S. no.	Sample	Water holding capacity (%)
1.	Onion bagging cloth	54
2.	Single layer gunny cloth	50
3.	Double layer gunny cloth	68
4.	Felt cloth	28
5.	Coir pith	60
6.	Charcoal	69

The water holding capacity of the packing materials (coir pith and charcoal) were found to be 60% and 66%, respectively. The water holding capacity of the material is the major factor in evaporative cooling system. Among six different types of materials the charcoal has appeared as the best insulation material, which has good water holding capacity this was due to large pore space volume. Thus, the charcoal was used as an insulation material in Low cost cooling system.

Conclusion

It was observed that the increase in bulk density of the packing material that was due to spraying of water/ soaking in water. The water holding capacity was high and significant for charcoal so this material was considered as a best insulation material and thus, this material reduce temperature and increased relative humidity levels compared to other insulation materials.

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