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EXPERIMENTAL PERFORMANCE EVALUATION OF AQUEOUS KCL AND PEG6000 SOLUTIONS AS EUTECTIC PHASE CHANGE MATERIAL (PCM) FOR PORTABLE COLD STORAGE APPLICATIONS

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INTRODUCTION

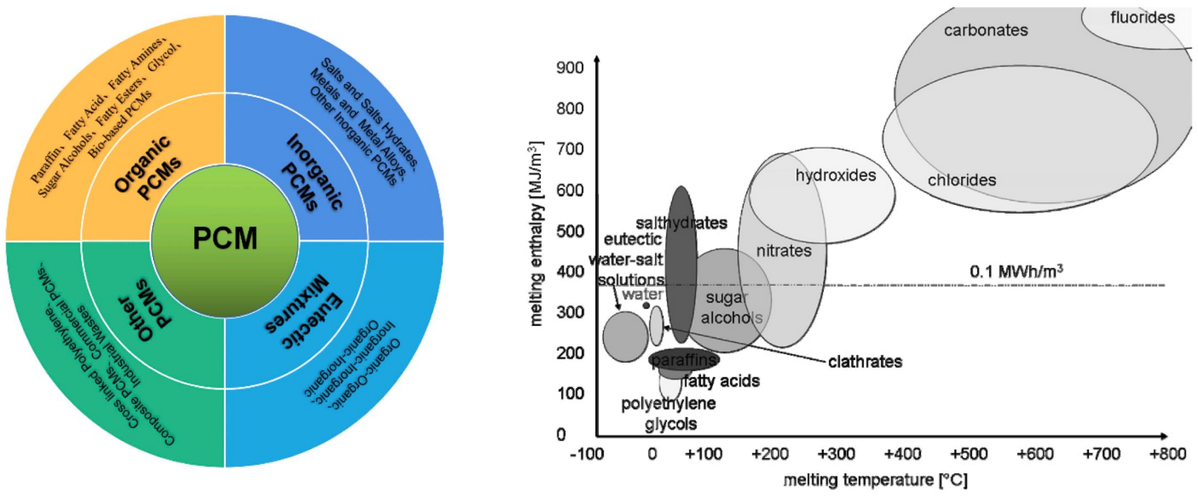
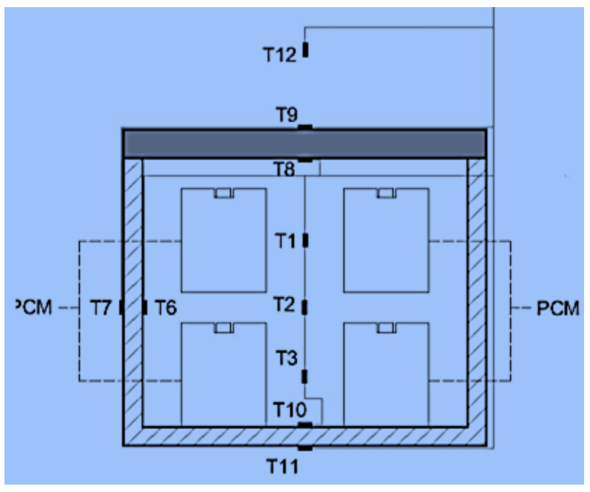


Fig. 1 Classification, melting temperature and melting enthalpy of PCM [1,2]

Worldwide, the Food and Agriculture Organization (FAO) reported a staggering annual waste of 1.3 billion tons of food. A significant portion of this waste, approximately 42%, can be attributed to vegetables and fruits [3]. This issue arises from challenges in distribution to remote regions and lengthy supply chains, leading to spoilage before reaching consumers. To preserve the freshness of perishable foods, which require cooler temperatures, recent advancements in cold storage technology have centered on employing phase change materials (PCM) in different configurations within cold storage [4].

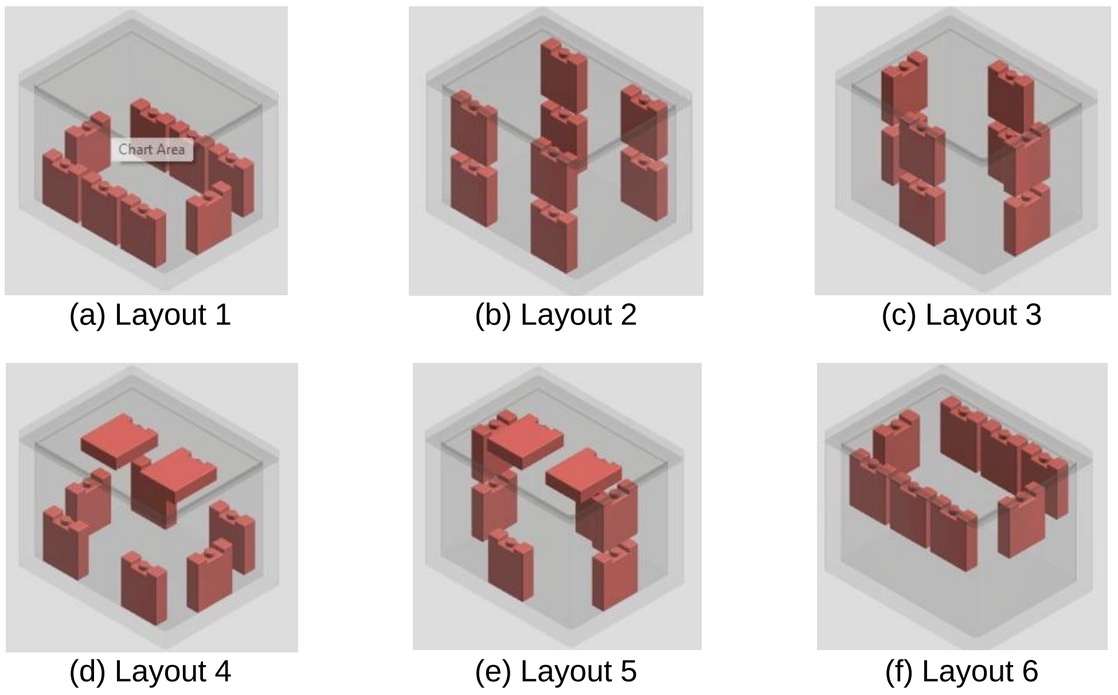
This research aimed to further enhance portable cold storage performance by using smaller packs, allowing for a broader range of configurations with phase change materials (PCM). On top of that, a comparison will be made between 10 wt% aqueous KCl and PEG6000.

EXPERIMENTAL METHODS



Measurement Points	
Middle Box	**Ambient**
¾ from bottom	Room Temp.
½ from bottom	
¼ from bottom	
Inside Wall	**Outside Wall**
Long side	Long side
Short side	Short side
Top	Top
Bottom	Bottom

Fig. 2 Measurement points



(a) Layout 1 (b) Layout 2 (c) Layout 3

(d) Layout 4 (e) Layout 5 (f) Layout 6

Fig. 3 PCM positions in the insulative container

The PCMs were put inside eight PCMs inside HDPE packs with a mass of 200 grams. The packs were placed in six different configurations in a portable cold storage measuring 340 mm x 255 mm x 285 mm. The measurements are focused on temperature distribution within the cold storage and heat transmission through its walls.

GOVERNING EQUATIONS

Cooling Capacity:

$$Q_{cooling} = Q_{trans} = \int_{t_{init}}^{t_{end}} k\,A\,\frac{(T_{w.in} - T_{w.out})}{L}\,dt \qquad (1)$$

Cooling Performance:

$$CP(\%) = \frac{Q_{PCM}}{Q_{Water}} \qquad (2)$$

RESULTS AND DISCUSSIONS

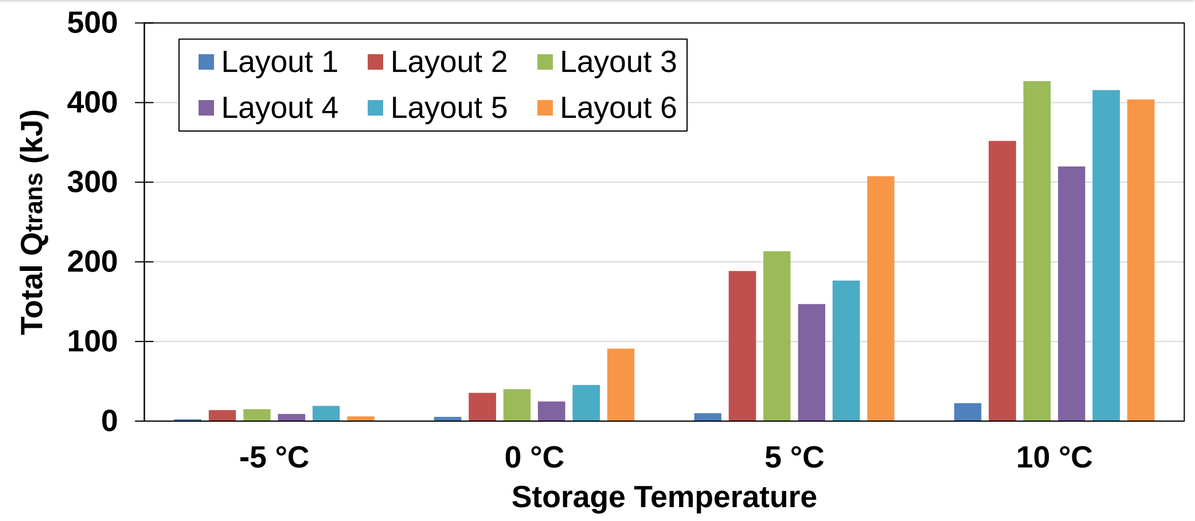


Fig. 4 Cooling capacity of portable cold storage in different PCM configurations using aqueous KCl 10 wt%

While layout 3 and layout 5 perform better at higher temperatures, layout 6 maintains good performance within the optimal storage temperature range for most vegetables and fruits, which is from 0 °C to 5 °C.

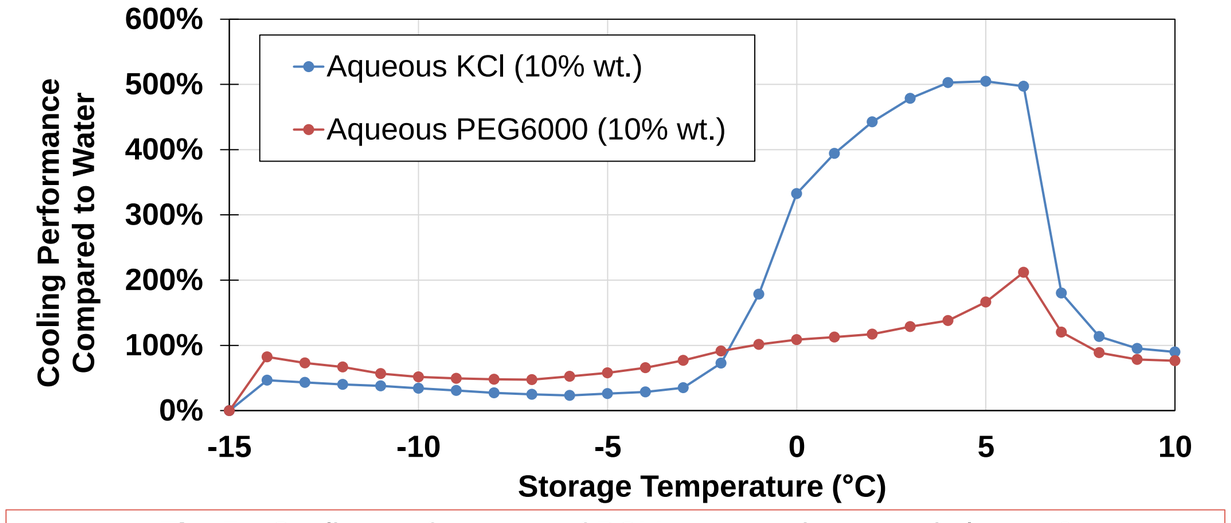


Fig. 5 Cooling performance of PCM compared to water in layout 6

Aqueous KCl and aqueous PEG6000 outperformed water at storage temperatures below 6 °C. The highest efficiency for aqueous KCl was achieved at 5 °C with a cooling capacity of 332 kJ, whereas aqueous PEG6000 reached its peak efficiency at 6 °C with a cooling capacity of 151.76 kJ.

CONCLUSIONS AND FUTURE WORKS

- The optimal performance was achieved by placing the PCM packs on the upper side of the portable cold storage. This setup minimized temperature fluctuations within the storage, making it more suitable for cold storage applications.
- an eutectic PCM comprising 10% of aqueous KCl demonstrated maximum effectiveness in maintaining temperatures above 5°C, with a maximum cooling capacity of 332 kJ. Conversely, 10% of aqueous PEG6000 was capable of sustaining temperatures above 6°C, with a maximum cooling capacity of 151,76 kJ compared to water.

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