heat to the environment. We are also assuming the water from the second leach (Fig. 2) may not be needed because there are cheaper cooling methods. By using experimentally determined values, we find that an additional 1865 kg of H_2O will need to be heated to 90°C from 25°C which requires 5.1 x 10^8 joules. Additionally, 570 kg of H_2O at 90°C will have to be evaporated. The joules required for evaporation will vary depending on the type of evaporator used. Assuming 1.09 kg of water can be evaporated with 1.02 x 10^6 joules (2.4 lb. per 970 BTU), then the 570 kg will require 5.3 x 10^8 joules for evaporation. This would give a total of 1.0 x 10^9 joules of extra energy consumed per metric ton of albedo processed. This amount of energy can be supplied by 454 kg (1000 lb.) of steam with a current cost of about $3.50 (5). However, the hot water leach process would yield approx 47 kg of 150 grade pectin in addition to increased naringin yields (2). These additional yields from the hot water leach process should more than adequately compensate for the small increase in the cost of energy consumed.

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EVALUATION OF HUMIDITY CONTROL PANELS FOR REFRIGERATED STORAGE OF CITRUS[1,2]

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Abstract. **Panels of a natural clay mineral have been used in meat storage and associated industries for desorption and adsorption of water to reduce relative humidity (RH) fluctuation and refrigeration operating time. Such panels were installed and tested for fresh citrus storage at the AREC, Lake Alfred at temp of 10 and 21°C. In all cases, average RH differential was less with the panels installed. However, the panels displayed high adsorption capacity above 80% RH. Refrigeration operating time was reduced by ca. 25% at 21°C. Equilibrium moisture contents were obtained to determine actual adsorption capacities. When the mineral directly contacted the fruit, specifically 'Marsh' grapefruit, no detrimental effects were noticed in subsequent 3 weeks storage.**

In general, citrus fruit are stored for shorter durations than deciduous fruit. However, environmental storage conditions are important as losses do occur from decay, desiccation and physiological disorders. Recommended storage conditions for citrus vary considerably depending upon the variety, geographic location, time of year and seasonal variations. ASHRAE (1) presents recommended *temp and relative humidity* (RH) conditions for various citrus varieties. For all varieties, RH above 85% is suggested. Such high moisture conditions are usually maintained through direct humidification or air-water counterflow refrigeration system as described by Deason and Grierson (2).

The more conventional direct humidification system results in additional costs since moisture is condensed on the evaporator coil. Usually, the coil is oversized, 0.5 to 1.5°C temp split, to reduce such problems by keeping temp above the dew point. An alternative to the increased cost caused by high humidity would be the incorporation of a material that would adsorb and desorb moisture, therefore, maintaining, a more uniform RH and partially reducing water condensation on the evaporator coils. According to Sereg (personal communication), such systems have been used for meat storage on an experimental basis. The research reported in this paper is an initial evaluation of this humidity control material (HCM) for fresh citrus storage.

Most adsorbent materials are used for extraction of vapor or gases brought into contact with them. The desorption phenomena is usually not encountered since the ambient partial vapor pressure is above that of the adsorbed vapor. Hence, their primary use has been in dehumidifying applications. The aggregate material used for humidity control in this study was a combination of calcite (45%), allophane (25%) and quartz (30%). Data on characterizing the material for adsorption water capacity is also included in this paper.

Materials and Methods

To establish design information on the moisture adsorbing characteristics of the HCM, a series of tests were conducted to establish equilibrium moisture content at various RH levels. Two temp were chosen, 4 and 21°C, which represent temp in the low and high range of citrus storage. Various RH conditions were established in sealed desiccators by using different concn of sulfuric acid and distilled water as described by Hall (3). Three oven-dried HCM samples, approx 50 g each, were placed in separate flat dishes and placed in each desiccator. Measurements of

[1]Florida *Agricultural* Experiment Stations Journal Series No. 849.
[2]The CNA Company, Ft. Lauderdale, Florida, is acknowledged for providing test materials and background information on moisture adsorbent minerals.

the sample's mass were made initially and after 2, 4, 8 and 24 hr. Readings were then taken on a 24 hr or multiple 24 hr basis. The size of the HCM particles varied considerably: from 2 cm diam nuggets to a fine 100-mesh size. The material was deposited on the plates in a single layer fashion. Density of sulfuric acid-water solution were checked at the conclusion of a set of tests to determine variations in RH.

Cold storage rooms at the AREC Lake Alfred packinghouse were used for evaluation of HCM panels in a simulated commercial application. The HCM was provided in cloth bags enclosed in perforated plastic trays. Mass of a panel and HCM were approx 2.7 kg. Two controlled temp rooms were used: one maintained at 21°C with a direct vapor compression unit and a second controlled at 10°C with a secondary glycol system. Refrigerated storage areas that would accommodate the HCM panels were not available at temp less than 10°C. Panels were installed in steel bracket frames approx 5.1 cm from the ceiling. The number of panels was based upon a company recommendation of one per 2.25 m^3 of air space plus an additional unit for each door. The amount of fruit varied from 1/3 to 1/2 room capacity as other researchers using the room were removing or adding citrus fruit. Panels were installed at least 3 days before testing to allow for moisture equilibration.

To monitor the effect of HCM panels, measurements of supplemental humidification time, compressor utilization time, room temp and RH were made. Lithium chloride RH sensors were used. The RH level was recorded with a strip chart recorder. Temp were recorded with a multi-point recorder from copper-constantan thermocouples. A hygrothermograph was used as a secondary measurement of temp and RH.

Results and Discussion

Both transient and steady-state relationships are important in refrigerated storage. Materials for humidity control must be able to adsorb and desorb moisture at rates equivalent to the cyclic variations of refrigeration equipment. In addition, total equilibrium moisture for a given RH and temp condition is an indication of reduced refrigeration load from condensation.

The HCM adsorbed moisture in an exponential fashion (Fig. 1 and 2). With increased RH, a direct increase in the equilibrium moisture content was noted. Experimental data were fit to an equation:

$$\% m_t = \% m_e - \% m e^{-at}$$

where

$\% m_t$—percent moisture content, dry basis, at any time, t
$\% m_e$—percent moisture content, dry basis at equilibrium
$\% m,a$—experimentally determined constants

Coefficients of determination for the experimentally fitted curves varied from 0.947 to 0.993. Times to adsorb 50% of the ultimate moisture at equilibrium ranged from 36.5 hr at 15% RH to 24.9 hr at 92.5% RH for 4°C and 26.6 hr at 70% RH to 23.1 hr at 92.5% RH for 21°C. Therefore, a considerable amount of the water would not be transferred in refrigeration cycling times typically encountered. These response times were based upon adsorption responses which, according to Sherwood et al. (5) are faster than desorption responses.

With equilibrium moisture conditions established at various RH levels, a plot of moisture content vs. RH was constructed at the 2 temp conditions (Fig. 3). The curve for 21°C was slightly above the 4°C curve throughout the experimental range. Such behavior is common for most

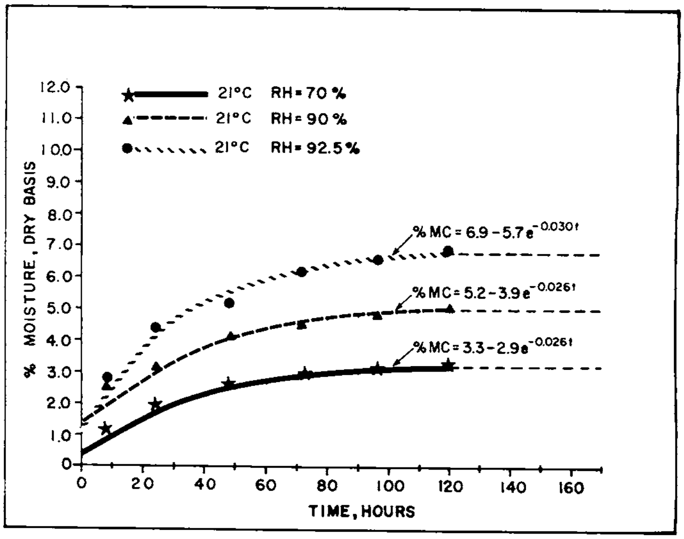

Fig. 1. Moisture adsorption of HCM at various humidity levels at 21°C.

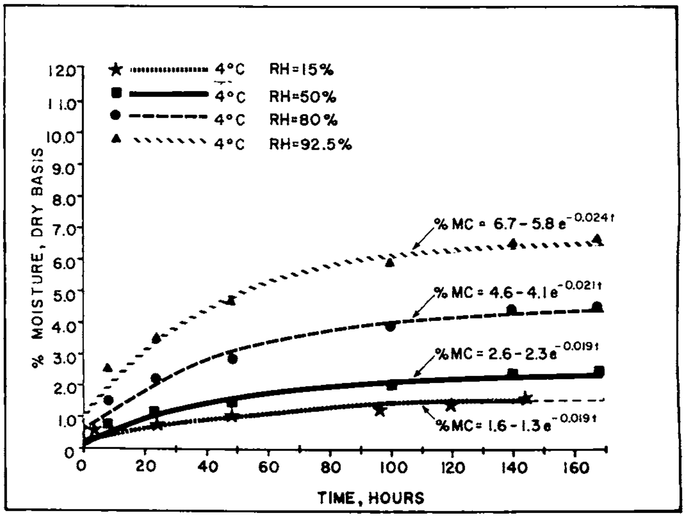

Fig. 2. Moisture adsorption of HCM at various humidity levels at 4°C.

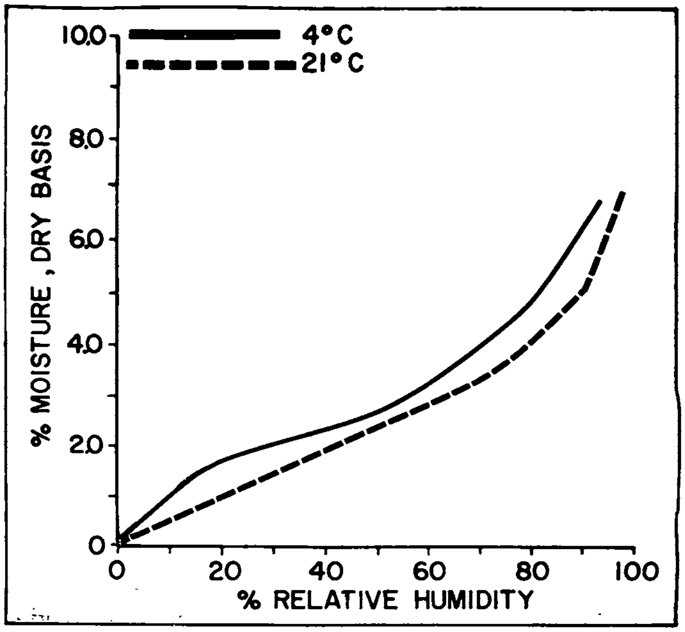

Fig. 3. Equilibrium moisture content for HCM at 4 and 21°C.

materials in the RH mid-range as discussed by Henderson and Perry (4).

Two tests were conducted at 10°C and 21°C with and without HCM panels. Humidity data were tabulated on an hourly basis and is summarized in Table 1. In general, the effect of the HCM panels was to reduce both maximum and minimum RH. An analysis of variance was performed on the data of humidity variation. Both panel installations and temp were significant. The large temp factor was a result of the direct-expansion refrigeration coil at 21°C.

Table 1. Average maximum and minimum RH conditions.

		With panels			Without panels		
		Max	Min	Diff	Max	Min	Diff
10°C	(Rep. 1)	91.0	87.2	3.8	92.2	88.7	3.5
	(Rep. 2)	91.1	87.4	3.7	92.4	88.0	4.4
	(Avg)	91.0	87.3	3.8	92.3	88.4	4.0
21°C	(Rep. 1)	83.4	70.9	12.5	83.7	72.2	11.5
	(Rep. 2)	79.5	72.4	7.1	83.6	71.9	11.7
	(Avg)	81.4	71.6	9.8	83.6	72.0	11.6

HCM panels reduced average refrigeration operating time from 0.235 hr/hr to 0.175 hr/hr for tests at 21°C, a reduction of ca. 25%. The effect of HCM installation at 10°C conditions was not measured since the refrigeration unit serviced 2 storage rooms. However, in all cases, the HCM reduced maximum humidity levels. This phenomenon was expected from data obtained on equilibrium moisture contents. Other mineral aggregate combinations may have more potential for the high humidity conditions which are required for citrus.

In Table 2, supplemental humidity requirements have been summarized. Humidity requirements at 10°C were significantly reduced by the panels but were not altered at 21°C. With greater moisture requirements at 21°C due to a higher vapor pressure difference and the type of refrigeration unit utilized, the panels were less effective.

In handling the HCM, a small amount of material filtered through the cloth bag container. To observe whether or not the material would cause any peel damage, 50 g of HCM was sprinkled on fruit from 2 cartons of 'Marsh' grapefruit. These samples, as well as control samples, were held at 15°C for 3 weeks and checked weekly for decay and abnormal skin disorders. Decay was minimal, less than 2%, and no skin blemishes were noted.

Table 2. Supplemental humidifying requirements for HCM tests.

Temperature	Panels	Humidifying time, hr/hr
10°C	Yes	0.09
10°C	No	0.14
21°C	Yes	0.04
21°C	No	0.04

No attempt was made to evaluate expected life of HCM, its odor adsorbing characteristics, nor its potential as an area for bacterial growth. These factors would be important in commercial applications and should be evaluated in further study.

Summary

Moisture adsorption characteristics for HCM were developed for 2 storage temp at intermediate to high RH levels. At 92.5% RH and 4 to 21°C, the material adsorbed 6.5 to 7.0% moisture dry basis. The HCM panels effectively reduced refrigeration operating time for fruit stored at 21°C with supplemental humidity requirements remaining constant. In all storage tests, the HCM reduced maximum humidity levels which may be objectionable if fruit desiccation is a primary concern. No detrimental effects were noted when HCM directly contacted 'Marsh' grapefruit.

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PACKINGHOUSE STRATEGIES FOR THE CONTROL OF FUNGICIDE RESISTANT MOLDS

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Abstract. **The resistance of citrus decay organisms to fungicides has become a considerable problem in handling fruit for the fresh market. Packinghouse design, as well as operation, has a profound effect on the extent to which resistant mold becomes a problem in an individual packinghouse. The methods used in three southern Arizona packinghouses to overcome the problems of design restrictions illustrate how resistant mold can be reduced to a manageable level by a combination of chemical treatments and minor modifications of existing equipment. These examples also indicate pitfalls to avoid in the layout of future packinghouses.**

The introduction of each of the fungicides presently approved for use on citrus has eventually been followed by the discovery of strains of decay organisms that are resistant to it. To date, strains of molds resistant to biphenyl, o-phenylphenol (OPP), sodium orthophenylphenate (SOPP), thiabendazole (TBZ), benomyl, and 2-amino-