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SURVEY OF ENERGY CONSUMPTION IN FLORIDA CITRUS PACKINGHOUSES[1]

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Abstract. **Survey results on energy use during the 1977-78 season were obtained in April 1979 from packers responsible for 57% of the commercial fresh citrus fruit packed in Florida. Energy efficiency comparisons were made on the basis of energy used per packed 4/5 bu carton. Energy consumption per packed carton ranged from 0.102 to 1.299 kWh electricity, 0.016 to 0.087 gal (0.061 to 0.329 liters) fuel oil, 0.171 to 6.858 cu ft (4.83 to 194.19 liters) natural gas, 0.004 to 0.011 gal (0.015 to 0.041 liters) propane for lift trucks and 0.003 to 0.012 gal (0.011 to 0.045 liters) gasoline for lift trucks. Each packinghouse shipped a season average of 14.5 to 276.1 thousand cartons per lift truck. Some citrus packers have indicated that they intend to make changes to improve energy efficiency on the basis of their observations while completing and studying the results of the survey.**

Energy costs have risen dramatically for Florida citrus packers as they have for other industries. Possible fuel shortages and high energy costs affect the harvesting, handling, packing, transportation and marketing chain for fresh citrus fruit.

The authors initiated a mail survey on energy consumption by sending questionnaires to the 85 members of the Florida Citrus Packers[2], who collectively ship approximately 95% of the state's fresh citrus. Representatives of 45 packinghouses completed and returned the survey. Those 45 firms packed 57% of the commercial fresh citrus fruit in Florida during the 1977-78 season (2). This survey provides a baseline of information on current energy use for future comparisons. Packers with relatively high energy use can see what can be accomplished and attempt to improve their operations. This survey also provides economic insight into the feasibility of alternate energy sources. This report is of energy consumed at the packing plants and does not include indirect energy inputs (waxes, cartons, etc.) or capital energy figures (machinery, buildings, boilers, etc.).

Griffiths (3) estimated that Florida citrus packinghouses used 0.8 kWh of electricity and 0.13 gal of Bunker C oil or equivalent fuel per 2.24 bu Florida field box handled in the 1973-74 season. That season, the average packout in Florida was 61.2% (5), so that the above figures would be 0.47 kWh and 0.076 gal per 4/5 bu carton packed. An intensive study was made of 2 orange, one lemon and one dual (orange and lemon) packing plants in California, reporting the utilization of electricity and natural gas (4). The orange packing plants used 1.13 and 1.55 kWh per 45 lb fruit packed, the dual plant used 1.71 and the lemon plant used 2.10. These four packing plants used 1.34 to 5.71 cu ft of natural gas per 45 lb fruit packed.

Although most of the citrus packinghouses with large volumes of fruit participated in this survey, over 60% of the firms packed between 25,000 and 825,000 cartons during the 1977-78 season (Fig. 1). The survey results represent a wide range of small to large packinghouses.

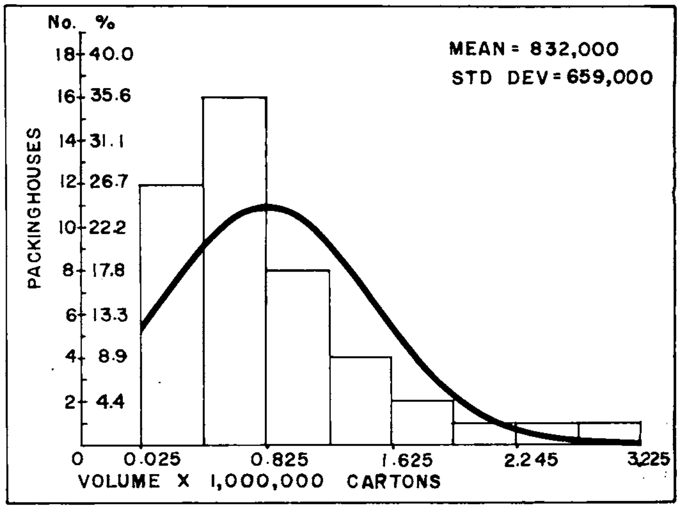

Fig. 1. Number of cartons packed during the 1977-78 season by 45 participants in the Florida citrus packinghouse energy consumption survey.

Survey Results

The results of the Florida citrus packinghouse energy survey are illustrated in a series of graphs. The number of packers responding to individual survey questions varied, hence the number of packers varies. Most of the larger packers (over 1,000,000 cartons packed per season) used natural gas whereas most of the smaller volume houses used oil (Fig. 2A, B). This natural gas or fuel oil was used to fuel boilers that provide steam for degreening rooms, fruit dryers, and color-add tanks. These are the larger energy consuming aspects of a citrus packinghouse. There was no apparent efficiency trend in fuel usage with size of operations. Natural gas use ranged from 0.17 to 6.86 cu ft (170 to 6860 BTU) per carton packed, whereas fuel oil use ranged from 0.016 to 0.087 gal (2736 to 13224 BTU) per carton packed. The 12 Florida citrus packers in this study with records on natural gas consumption used about the same rate per 4/5 bu carton as did 4 California citrus packinghouses studied by Naughton, et al. (4). The 1973 estimate of fuel oil used by Florida citrus packers (3) is higher than that used by most of those responding to this survey.

Electrical consumption ranged from 0.102 to 1.299 kWh per carton packed (Fig. 2C) with no apparent relationship to size of packinghouse. However, there was a significant increase of electrical usage per carton packed with increasing refrigeration (Fig. 3). The report for 4 California packing plants (4) indicated values of electrical usage higher than for Florida packers (Fig. 2C). These higher California values are probably due to greater use of refrigeration, with some lemon storage up to 6 months. The 1973 estimate for electri-

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[2]The authors thank Mr. James Emerson, General Manager, Florida Citrus Packers, for his assistance in distributing the survey and encouraging his members to participate.

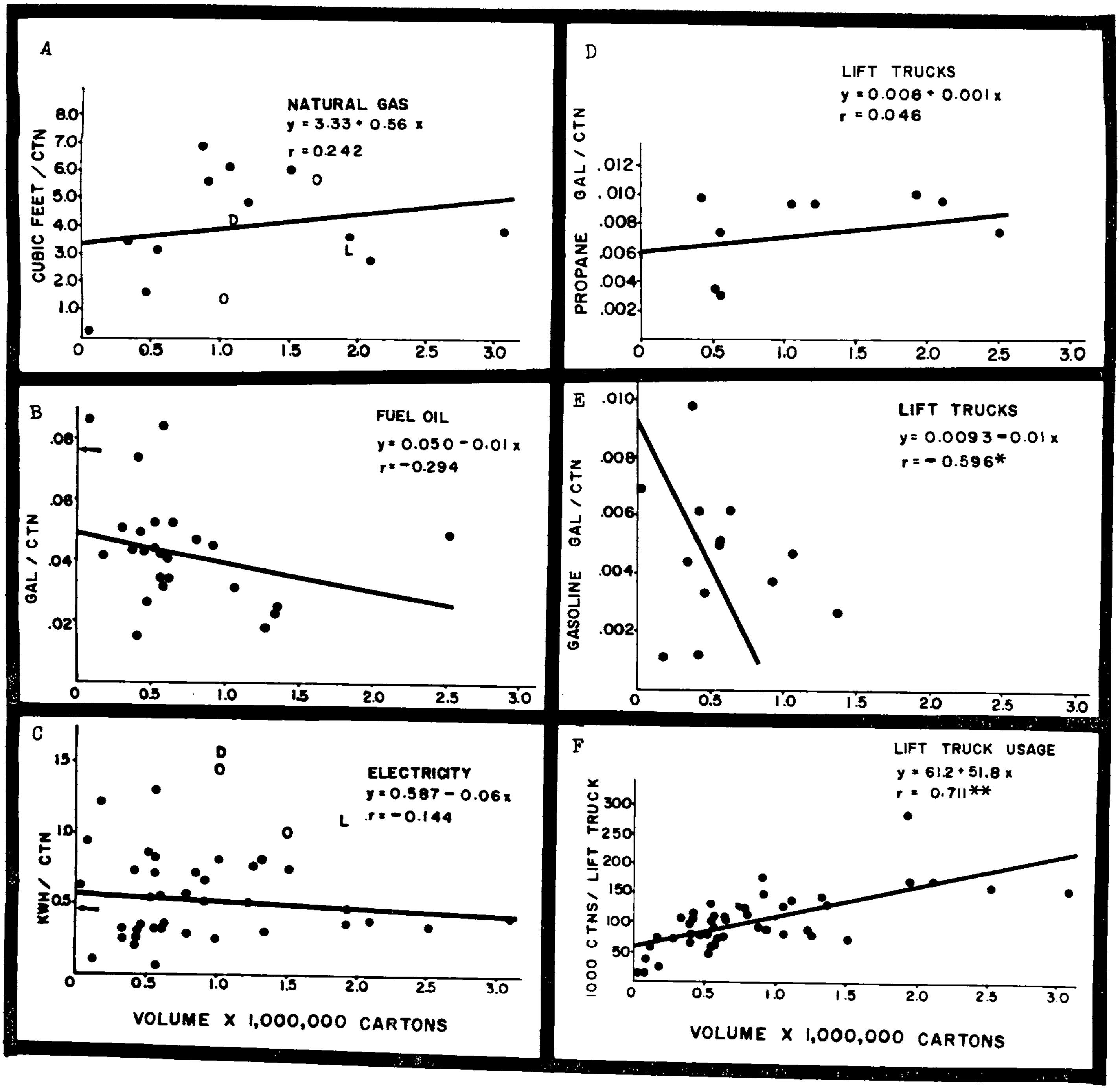

Fig. 2. Data from Florida citrus packinghouse energy consumption survey. California citrus packers are included for comparison in A and C, i.e.: O & O packed only oranges, L packed only lemons and D packed both lemons and oranges (4). A 1973 report of usage by Florida citrus packers is indicated by arrows in B and C (3). A. Natural gas usage, as cubic feet per carton of citrus packed, for 12 packers. B. Fuel oil usage as gallons per carton of citrus packed, for 25 packers. C. Electricity consumption, as kWh per carton of citrus packed, for 38 citrus packers. D. Gallons of propane used by lift trucks per carton of citrus packed, for 9 citrus packers. E. Gallons of gasoline used by lift trucks per carton of citrus packed, for 13 citrus packers. F. The lift truck usage as 1000 cartons packed during a season per lift truck operated, for 45 citrus packers.

cal usage by Florida citrus packers (3) is comparable for those supplying data in this survey for the 1977-78 season.

Lift truck propane (Fig. 2D) and gasoline (Fig. 2E) use in gal per carton packed varied about four-fold for those packers with such records. There was a significant increase in efficiency for gasoline lift truck fuel for larger packers (Fig. 2E). Comparisons could not be made for those packers with a combination of propane, gasoline and/or electrical lift trucks. The efficiency of lift truck use is illustrated in Fig. 2F, wherein the amount of fruit packed in a season per lift truck is significantly greater for larger packinghouses. The larger packinghouses better utilized their lift trucks, the range being 14,500 to 276,100 cartons packed in a season per lift truck. This variability can be greatly influenced by design of the packinghouse, the length of normal lift truck runs and partial lift truck use in the carton assembly area.

Those 20 packers supplying data in all categories were compared for total energy consumed at the packinghouse by converting the various energy units to a common factor of Joules per carton packed (Fig. 4). Electrical consumption was converted to power generation requirement using 32.5%

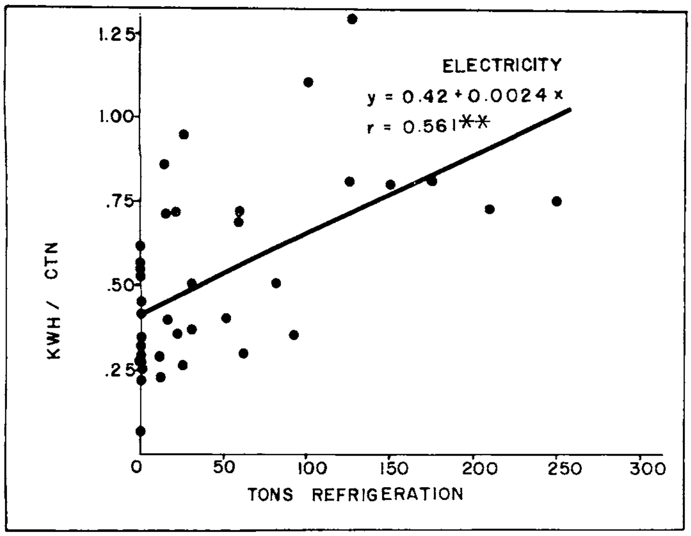

Fig. 3. Electricity consumption as kWh per carton of citrus packed vs. tons of refrigeration for 38 Florida citrus packers.

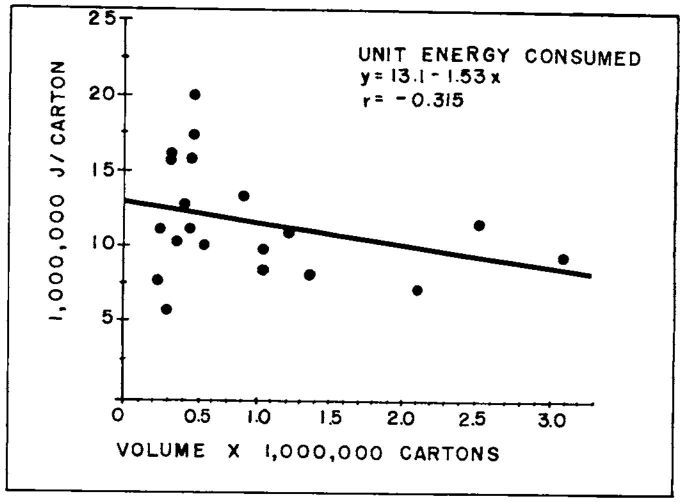

Fig. 4. The energy consumed in 20 Florida citrus packinghouses expressed as Joules per carton packed. Values for electricity, fuel oil or natural gas, and lift truck fuel are included in these values.

conversion efficiency. Heating value for fuels were taken from ASHRAE (1). There is no significant correlation for energy consumption per carton packed to the size of packinghouse, however, there is a trend for larger operations to be more efficient.

The usefulness of this survey has been realized by individual citrus packers. Some packers have found that they apparently use larger amounts of energy from one source and have already taken steps to correct the problem. Other packers realized the importance of accurate and complete records. In some cases, lack of separate meters precluded full participation in this survey. Several of these packers have taken steps to correct this situation.

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ENERGY REQUIREMENT OF THE TASTE CITRUS JUICE EVAPORATOR AND ITS REDUCTION BY AUTOMATIC CONTROL—A PILOT PLANT EVALUATION[1]

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Abstract. **A pilot plant study of heating energy required for citrus juice evaporation using a TASTE evaporator is reported. A comparison of energy used during both automatic and manual control is presented. Automatic and manual evaporator control methods are compared by means of steam rate, juice feed rate and pumpout Brix data sensed and recorded instrumentally each minute during each type of control. The automatic control experiment required a steam use rate 19% lower than the manual control while the same work was done in each experiment.**

The Florida citrus industry annually spends almost 11 million dollars on fuel to produce steam for frozen concentrated orange juice (FCOJ) evaporation (3). In 1975 the Florida Citrus Processors Assn. indicated a need for research in automatic process controls as a means to reduce energy required for evaporation of citrus juices. Such a study was funded by the Florida Department of Citrus in 1976 and succeeding years. Work has been accomplished by the Florida Department of Citrus Scientific Research Staff in cooperation with the University of Florida, IFAS research staff at the Agricultural Research and Education Center, Lake Alfred.[2]

Progress of this research has been presented at annual AREC Processors Meetings (1, 2, 4). This paper will compare recent results of both manual and automatic evaporator control experiments.

Materials and Methods

Instrumentation and techniques of monitoring tempera-

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