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Performance Test of a Solar Refrigerator Temperature on Water, Milk and Honey

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***Abstract*— Solar-powered refrigerators and other solar appliances are commonly used by individuals living off-the-grid. They are able to keep perishable meat and dairy cool in hot climates. Solar refrigerators are very useful as an alternative to absorption refrigerators, as they can be safely left running year-round. The irregular and not constant supply of power in the developing country and non-availability of power grid in the rural communities prevent the use of conventional electrical refrigerator in rural areas. 50cm3 each of water, milk and honey were wrapped put in the solar powered and electrically powered refrigerators for the laboratory bench work. The water, milk and honey samples initial temperature both tin and nylon were 26 0C, 39 0C and 34 0C respectively and readings were taken after every 20 minutes.**

***Index Terms*— Solar-powered refrigerators, Solar Energy.**

I. Introduction

Highlight Industrial refrigerator is one of the most energy consuming sector. By producing an absorption refrigeration system one may not only be cutting down the energy costs but also preserving our environment. This refrigeration system does not use any of the CFCs so our ozone layer is safe. Greenhouse gases and their damaging effects on the atmosphere have received increased attention following the release of scientific data by United Nations Environment Programme and World Meteorological Organization that show carbon dioxide to be the main contributor to increase global warning (UNEP, 2005).The domestic refrigerator freezers operating on alternative refrigerants such as Hydroflourocarbon (HFC) contribute indirectly to global warning by the amount of carbon dioxide produced by the power plant in generating electricity to operate over a unit. This contribution is nearly 100 times greater than the direct contribution of the refrigerant alone (Burton, 2007).

Solar power is energy from sun that is harnessed using a range of ever evolving technologies such as solar heating, photovoltaic (solar electric), solar thermal energy etc. Modern technologies can harness this energy for a different purpose including generating electricity, providing light, and heating water for domestic, commercial, or industrial use. Solar energy is the cleanest and it is an important source of renewable energy ,it gathers solar energy in form of sunlight and it is converted into direct current(DC) in which its technologies are broadly characterized as either Active solar and Passive solar depending on how they capture and distribute solar energy or convert it into solar power (Pedersen, Poulsen and Katic, 2012). Active solar system which are solar thermal energy, photovoltaic (solar electric), and solar heating uses mechanical or electrical device that converts the sun's heat or light to another form of usable energy, while passive solar buildings are designed and oriented to collect, store and distribute the heat energy from sunlight to maintain the comfort of occupants without movement (Luo, Tang, Liu, and Wang, 2005).

Numerous purposes were being considered for solar energy as an energy resource to meet the needs of developing countries, such as Nigeria. Solar-powered refrigerators and other solar appliances are commonly used by individuals living off-the-grid. They are able to keep perishable meat and dairy cool in hot climates. Solar refrigerators are very useful as an alternative to absorption refrigerators, as they can be safely left running year-round. In this paper, performance test of vapour compression refrigeration system (VCRS) and vapour absorption refrigeration system (VARS) operated by a solar PV array carried out. The irregular and not constant supply of power to our towns and cities by the Power Holding Company of Nigeria and non-availability of power grid in our rural communities prevent the use of conventional electrical refrigerator in rural areas. It is against this background and others that this study is embarked upon.

II. METHODOLOGY

Commercially available -:1 bottle $(50\ cm)^3$ of water, 1 bottle $(50\ cm)^3$ of milk and 1 bottle $(50\ cm)^3$ of honey were purchased and stored for later use. These fluids were wrapped in nylon, tin and plastic during the experiments and kept in the solar powered and electrically powered refrigerators for the laboratory bench work at different period of time. The water sample initial temperature in tin and nylon were 26 ^{0}C. The readings were taken after every 20 minutes (see Tables 1and 4). The same procedure was repeated for milk but at initial temperature of 39 ^{0}C (see Tables 2 and 5). Also for honey sample, but at initial temperature of 34 ^{0}C (see Tables 3 and 6).

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III. RESULTS

Table 1: Effect of Temperature on Water using Solar Refrigerator

S/ NO	TIME	WATER IN TIN	WATER IN NYLON
1.	0 MINS	$26^{O}C$	$26^{O}C$
2.	20 MINS	$10^{O}C$	$3^{O}C$
3.	40 MINS	$9^{O}C$	$1^{O}C$
4.	60 MINS	$6^{O}C$	$0^{O}C$
5.	80 MINS	$5^{O}C$	$8^{O}C$
6.	100 MINS	$7^{O}C$	$2^{O}C$
7.	120 MINS	$5^{O}C$	$2^{O}C$
8.	140 MINS	$4^{O}C$	$4^{O}C$

Table 2: Effect of Temperature on Milk using Solar Refrigerator

S/ NO	TIME	MILK IN TIN	MILK IN PLASTIC
1.	0 MINS	$39^{O}C$	$39^{O}C$
2.	20 MINS	$16^{O}C$	$25^{O}C$
3.	40 MINS	$18^{O}C$	$20^{O}C$
4.	60 MINS	$15^{O}C$	$10^{O}C$
5.	80 MINS	$12^{O}C$	$18^{O}C$
6.	100 MINS	$8^{O}C\ ^{O}C$	$14^{O}C$
7.	120 MINS	$8^{O}C$	$17^{O}C$
8.	140 MINS	$8^{O}C$	$13^{O}C$

Table 3: Effect of Temperature on Honey using Solar Refrigerator

S/ NO	TIME	HONEY IN TIN	HONEY IN PLASTIC
1.	0 MINS	$34^{O}C$	$34^{O}C$
2.	20 MINS	$23^{O}C$	$22^{O}C$
3.	40 MINS	$16^{O}C$	$22^{O}C$
4.	60 MINS	$14^{O}C$	$13^{O}C$
5.	80 MINS	$15^{O}C$	$15^{O}C$
6.	100 MINS	$15^{O}C$	$17^{O}C$
7.	120 MINS	$2^{O}C$	$7^{O}C$
8.	140 MINS	$9^{O}C$	$10^{O}C$

Table 4: Effect of Temperature on Water using A.C Refrigerator

S/N O	TIME	WATER IN PLASTIC
1.	0 MINS	$30^{O}C$
2.	20 MINS	$14^{O}C$
3.	40 MINS	$12^{O}C$
4.	60 MINS	$11^{O}C$
5.	80 MINS	$11^{O}C$
6.	100 MINS	$10^{O}C$
7.	120 MINS	$10^{O}C$
8.	140 MINS	$11^{O}C$

Table 5: Effect of Temperature on Milk using A.C Refrigerator

S/N O	TIME	MILK IN TIN
1.	0 MINS	$32^{O}C$
2.	20 MINS	$20^{O}C$
3.	40 MINS	$16^{O}C$
4.	60 MINS	$13^{O}C$
5.	80 MINS	$12^{O}C$
6.	100 MINS	$12^{O}C$
7.	120 MINS	$11^{O}C$
8.	140 MINS	$11^{O}C$

Table 6: Effect of Temperature on Honey using A.C Refrigerator

S/N O	TIME	HONEY IN TIN
1.	0 MINS	$32^{O}C$
2.	20 MINS	$18^{O}C$
3.	40 MINS	$14^{O}C$
4.	60 MINS	$13^{O}C$
5.	80 MINS	$12^{O}C$
6.	100 MINS	$12^{O}C$
7.	120 MINS	$11^{O}C$
8.	140 MINS	$12^{O}C$

Table 7: Comparison between the effect of Temperature on Milk using Solar and A.C Refrigerators

S/ NO	TIME	MILK IN TIN (solar)	MILK IN TIN (A.C)
1.	0 MINS	$39^{O}C$	$32^{O}C$
2.	20 MINS	$16^{O}C$	$20^{O}C$
3.	40 MINS	$18^{O}C$	$16^{O}C$
4.	60 MINS	$15^{O}C$	$13^{O}C$
5.	80 MINS	$12^{O}C$	$12^{O}C$
6.	100 MINS	$8^{O}C$	$12^{O}C$
7.	120 MINS	$8^{O}C$	$11^{O}C$
8.	140 MINS	$8^{O}C$	$11^{O}C$

Table 8: Comparison between the effect of Temperature on Honey using Solar and A.C Refrigerators

S/ NO	TIME	HONEY IN TIN (solar)	HONEY IN TIN (A.C)
1.	0 MINS	$34^{O}C$	$32^{O}C$
2.	20 MINS	$23^{O}C$	$18^{O}C$
3.	40 MINS	$16^{O}C$	$14^{O}C$
4.	60 MINS	$14^{O}C$	$13^{O}C$
5.	80 MINS	$15^{O}C$	$12^{O}C$
6.	100 MINS	$15^{O}C$	$12^{O}C$
7.	120 MINS	$2^{O}C$	$11^{O}C$
8.	140 MINS	$9^{O}C$	$12^{O}C$

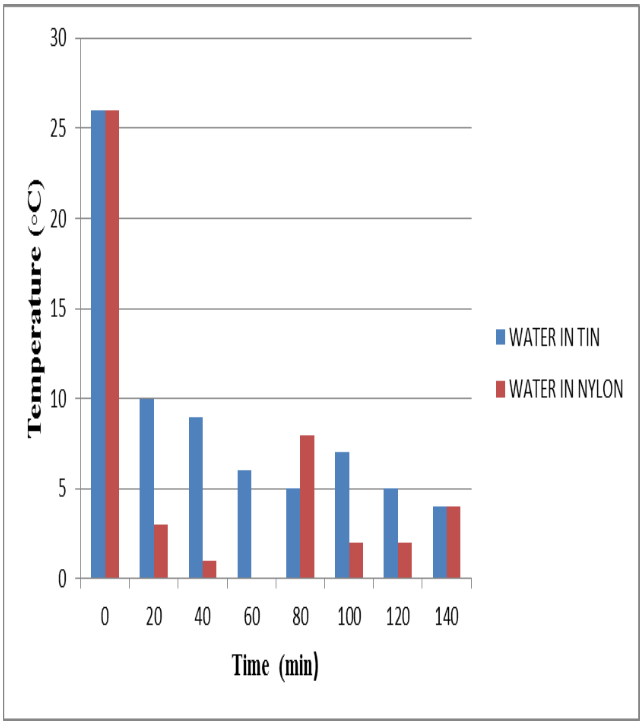

Figure 1: Graph of Temperature against time of Water using Solar Refrigerator

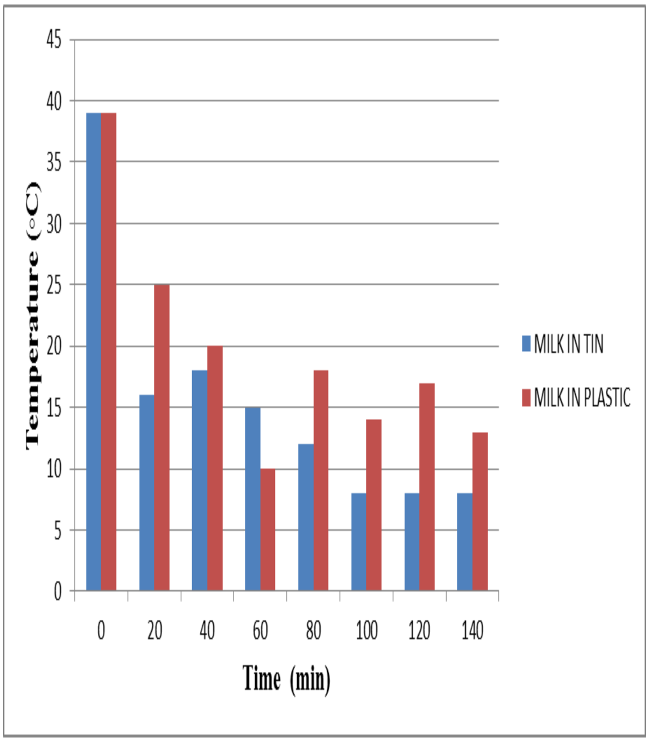

Figure 2: Graph of Temperature against time of Milk using Solar Refrigerator

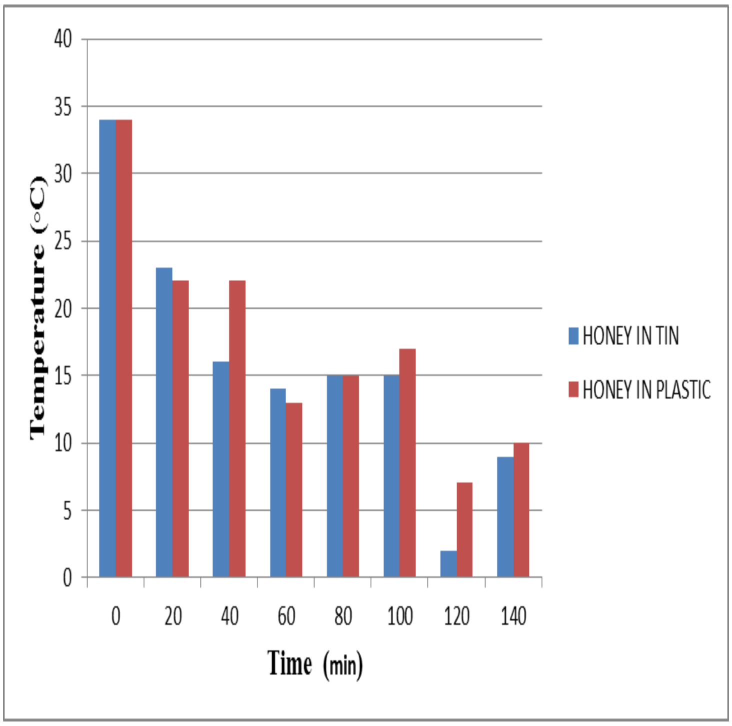

Figure 3: Graph of Temperature against time of Honey using A.C Refrigerator

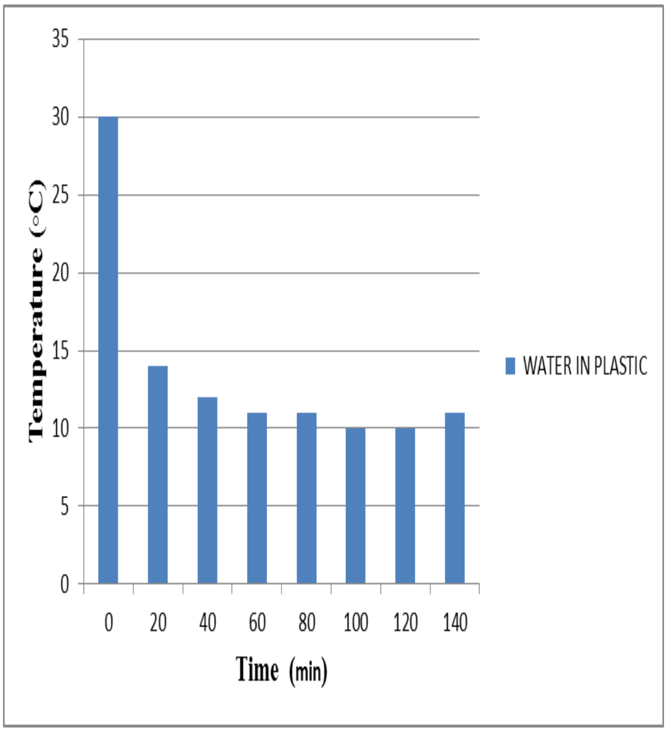

Figure 4: Graph of Temperature against time of Water using A.C Refrigerator

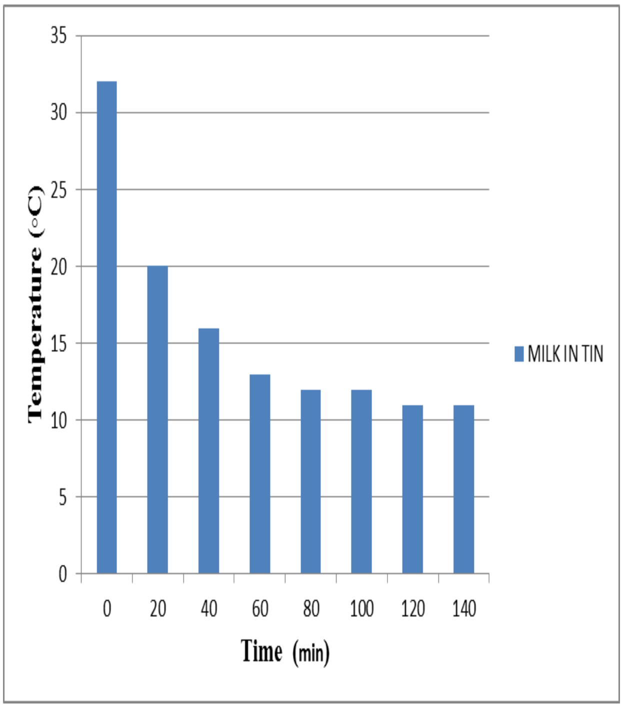

Figure 5: Graph of Temperature against time of Milk using A.C Refrigerator

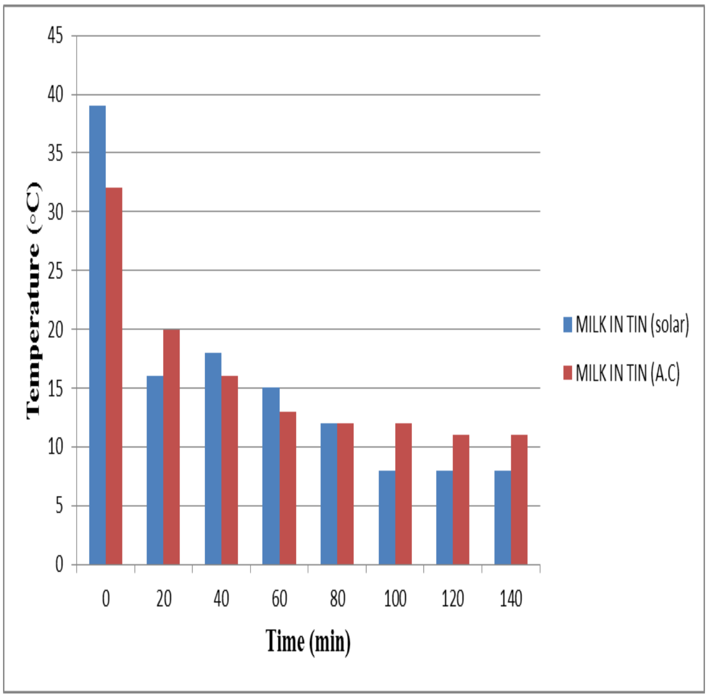

Figure 7: Graph of Temperature against time of Milk using Solar and A.C Refrigerators

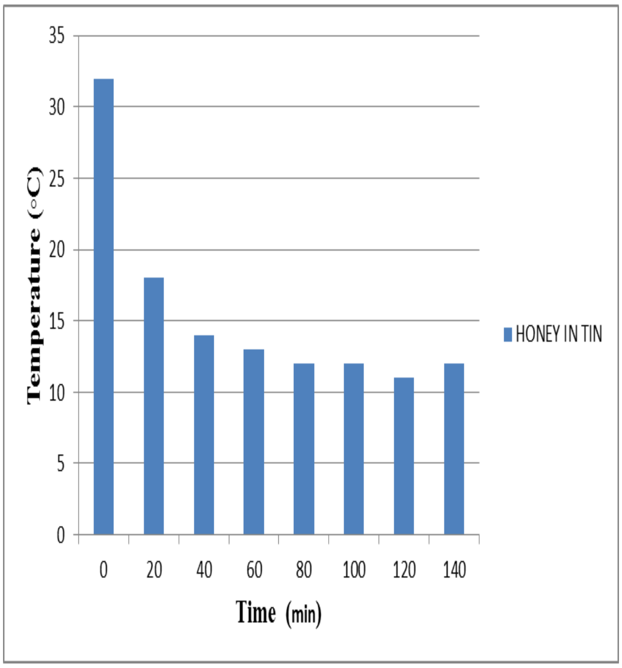

Figure 6: Graph of Temperature against time of Honey using A.C Refrigerator

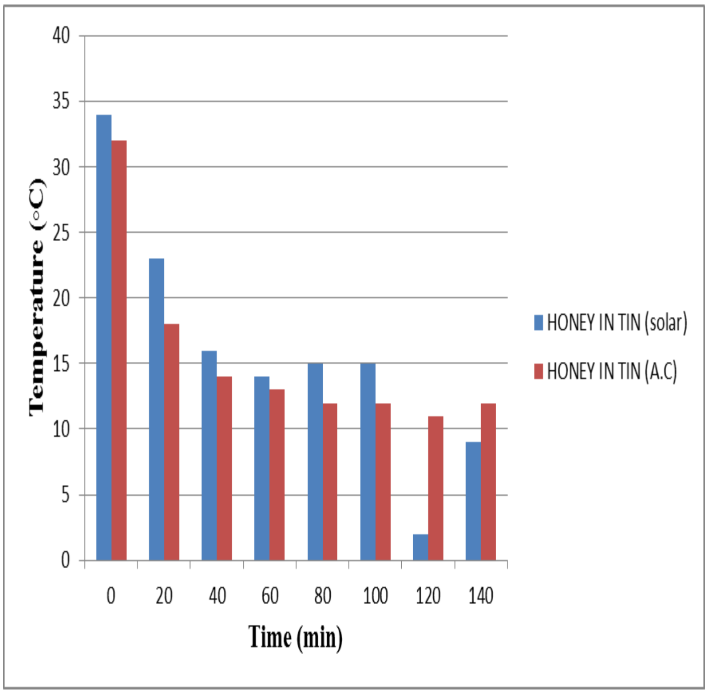

Figure 8: Graph of Temperature against time of Honey using Solar and A.C Refrigerators

IV. DISCUSSION

From the figure 1 it was revealed that out of all experiments carried out, it was on experiment three that the temperature of water in tin was higher than that of rice in plastic. All other experiments as regards water in tin and in plastic, temperatures of coldness of water in plastic were higher than that of water in tin this may not be far fetch from the fact that plastic absolve coldness slower but rises faster than tin. In figure 2 it was observed that milk in nylon only showed higher coldness than that of milk in tin in experiment four and both milk in nylon and in tin were equal in experiment seven. Asides these, milk in tin showed higher coldness than that of milk in nylon. However, figure 3 recorded that only on experiment one that honey in tin showed higher coldness than that honey in plastic, all other six experiments honey in plastic showed higher coldness compared to honey in tin.

However, the temperature profile inside the refrigerator is same irrespective of mode of supply either from grid or solar. However in both the supplies minimum 190V AC is required to run the compressor. In case of PV if battery is not charged to deliver starting current then inverter does not allow the compressor to start whereas, in the case of grid supply this problem does not arise. Meanwhile, in VARS, the battery discharged at a very slow rate on the other hand in the VCS battery discharged at a high rate due to more running current as well as high starting currents.

Also, the VCS has nearly 1:2 on off cycle so number of starting required is more hence more times the high value of current from battery is required consequently battery discharged quickly.

As a result of high starting current in the VCS, it required battery more than 50% charged and larger inverter capacity to handle the large amount of current. Where as in the case of VARS small capacity inverter may be used.

V. CONCLUSION

Technically it is feasible to operate refrigerators as photovoltaic refrigerators. Under normal operating conditions, refrigerator working on photovoltaic power supply, behave similar to working on grid electricity. Performance test shows that solar refrigerator system has a very high cooling rate and more power consumption in comparison to refrigeration system with grid. It may be recommended that if a high cooling rate is required frequently one could select vapour compression solar refrigeration system and if only the temperature is to be maintained in the cabinet then the vapour absorption system is capable with less capital investment than compression system.

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