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Review Article

Study of Thermoses for Maintaining Food Hot at Educational Centers and Offices

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Abstract

In addition to promoting the use of Solar ovens for warming lunch at Educational Centers and offices etc. another option is provided like the use of some appropriate Thermos bottles. Have observed different types of thermoses to maintain the meal hot from 2 to 25 hours, from the time you have left home. Fortunately, some thermoses are Microwaveable, and some can be used in solar oven too, with additional benefits. Only five thermoses are studied to see their effectiveness by observing the fall in temperature after 5 hours. Also heat loss coefficients and calculated thermal conductivity are mentioned.

Keywords: Heating Meal; Solar Energy; Solar Ovens; Thermos Bottles; Heat Loss Coefficient

Introduction

Author has been working and using Solar Cookers/Ovens, for cooking and heating meals for last about 45 years, for saving electrical energy and to promote so that the users can have hot meals with low consumption of electrical energy. Experience has shown that it takes about 2.5-3 minutes to heat lunch in 1 Microwave oven. I consider myself as one of the longtime users of Solar Oven at my house and at my office (while working) for heating my lunch in Costa Rica, whenever climate permits. At my place of Heredia, I can heat meals for about 11 months in a year as compared to only about 7-8 months in a year for cooking [1-5].

According to my observation almost everyone carries meals in plastic pots and use Microwave ovens for heating lunch. Some students and parents are also worried about the use of microwave radiations for heating meals.

I promoted the use of Solar Ovens for heating meals [4]. Where one Solar oven of size about 0.6-0.7 m^2, could heat about 40 lunch boxes in about 2 hrs. - ready by midday, normal lunch break. It has main advantage, as compared to heating microwave oven. Here Solar Oven can heat lunch boxes, while students are busy taking their regular class. Although with many advantages [2] but due to comparatively higher cost, many educational institutes cannot install solar ovens. Even some students get scared that UV solar radiation can harm the meal. With my promotional work (but not seller) in Costa Rica, about 30-32 Schools/colleges have/installed about 100 solar ovens of different sizes for heating meal.

On the other hand, many people carry thermos bottles for water, juice, tea, coffee etc. but not for carrying meals. In the present article this option is considered, carrying the heated meal in thermos bottles to keep the food hot until lunchtime. That is the main objective of this paper.

Types of thermos bottles

There are hundreds of Thermos on the market for maintaing the product (liquid or meal) hot and cold as well. Some are basd on heat Insulating materials, some with vacuum as insulation and some with both. Here we plan to study Thermos only for carrying meals.

Seeing many thermos on the market, I classify them under following categories.

- Thermos indicating number of hours to maintain food Hot (or Cold). I will prefer if the food is maintaied hot for at least 5 hours from leaving house,
- Thermos made of complete plastic materials, which can be heated directly in Microwave Ovens too,
- Thermos having also heat generating phase change material inside,
- Thermos having 12VDC Electric input for using in cars or educational centers having solar panels.

Although four types are studied, but in this manuscript only the results of first two types are reported.

Experimental study

Although some thermoses indicate how long the meal will be maintained hot but does not mention any indication of minimum meal temperature to enjoy. To have some idea, I assume one hour of travel from home to the educational centers/ office and then another 4 hours of studying/working before taking lunch. It means I would like to know the meal temperature 5 hours after leaving home. Regarding the temperature required for enjoying the meal, I am assuming temperature of at least about 40°C. Thus, in addition to measuring initial meal temperature at home, I have also measured temperatures after 4, 5 and 6 hours, to know the effectiveness of Thermos.

To study the effectiveness of thermos, either one can study the fall in meal temperature with time or calculate the Heat loss Q (J/s or Watts) or calculate the thermal conductivity, if all the materials, their thickness, surface area etc. are known.

Most probably the possible users will be carrying the thermos with meal in some thermal bag, which in general should increase more time for keeping the meal hot. Thus, I have studied the performance of each thermos with and without thermal bag, to see extra temperature gained.

In all experiments about 250g of heated pinto (mainly rice and beans with natural spices etc.) is put in the thermos. Meal and ambient temperatures are measured every 30-60 minutes, until meal temperature is reached to body temperature 37 - 40 °C. Then the same thermos with the similar heated meal is put in thermal bag (Photo 1) and both data are measured again to note the differences.

Photo 1: Thermal bag for carrying different thermoses.

Thermos type 1. Indicating time for maintaining food hot

Earthy the Mug, (Photo 2), 18/8 Stainless Steel, Double wall with vacuum, 414 ml. 8 hrs. Hot and 20 hrs. Cold, details www.earthycr.com.

Photo 2: Earthy Thermos.

Data are measured on Feb. 20 and Feb. 23, 2026, March 18 and March 20, 2026, but the results are reported only for Feb. 20, 2026 (without thermal bag) and March 18, 2026 (with thermal bag), Figures 1a and 1b.

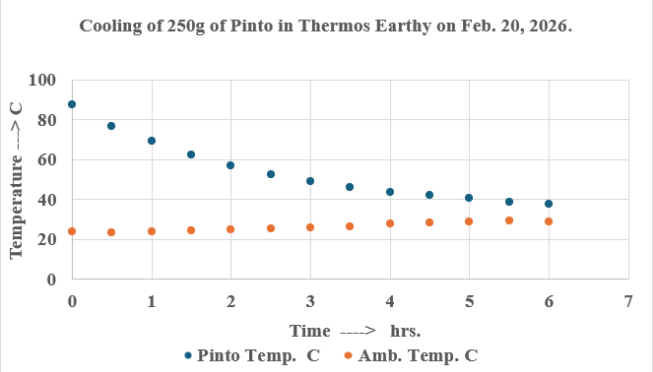

Figure 1A: Cooling of Pinto in Thermos Earthy on Feb. 20, 2026, without thermal bag.

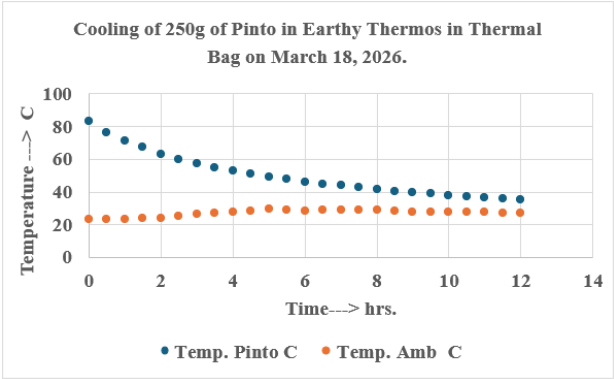

Figure 1b: Cooling of Pinto in Thermos Earthy on March 18, 2026 with thermal bag.

In short, on Feb. 20, 2026, the meal temperatures in the beginning (at house), after 4 and 5 hours are 87.8, 43.7 and 40.1 °C respectively without thermal bag, where as on March 18, 2026, these are 83.1, 52.8, and 49.5 °C, respectively, with thermal bag. We see the advantage of about 9 °C at lunch time (5 hrs.) compared to without using the bag. Although we made similar study with diffferent thermoses but we will show the measurements only with thermal bag.

Thermo Flask (Photo 3), capacity 355 ml, 7 hrs. hot and 14 hours cold, BPA Free, Dishwasher Safe, details mythermoflask.com

Photo 3: Thermo Flask.

Data have been measured on Feb. 23, Feb. 24 and March 10, 2026. However here the results are reported only for March 10, 2026 (Figure 2).

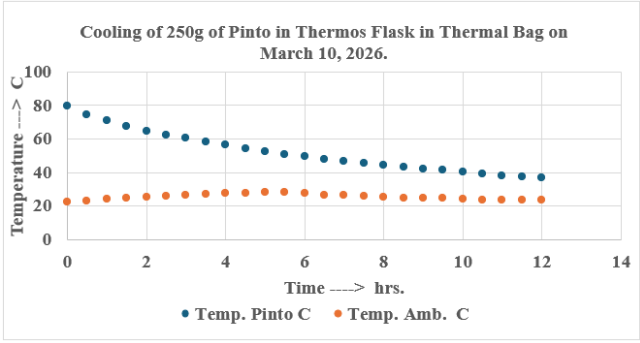

Figure 2: Cooling of Pinto in Thermo Flask, on March 10, 2026 with thermal bag.

In short on Feb. 24, 2026, meal temperatures initially, after 4 and 5 hours are 88.6, 49.7 and 44.5 °C respectively without bag and for March 10, 2026 are 79.8, 56.4 and 52.2°C, respectively with thermal bag. Again we see the gain of about 8 °C with thermal bag at lunch time.

Buba Growler, Big thermos, Photo 4, 1.9l, 26 hrs. Hot and 80 hrs. Cold. guaranteed for life. Chicago.

Photo 4: Thermos Buba Growler.

Due to big capacity and narrow mouth, it may not be practical for carrying lunch for one person, however it is used for carrying water or other liquid for whole day. Thus, I have studied its thermal behavior of cooling 1 l of hot water (better would have been coffee), on Jan. 28, 29, 30, 2026 and on March 2, 2026. But data are reported only for March 2, 2026 (Figure 3).

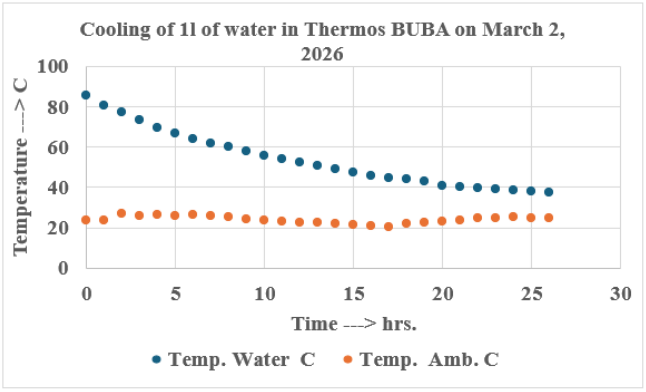

Figure 3: Cooling of 1l of water in Thermos on March 12, 2026 without thermal bag.

The water temperatures measured on March 2, 2026 are 85.8(initial), 66.8 (5 hrs.), 55.8(10 hrs.) 44.2 (18hrs.) and 40 °C after 23 hrs**.** Thus it looks as one of good thermos as can maintain 1 l of water/coffee hot for about 23 hours, even without using thermal bag. Being not practical for a single person, I did not prefer to study with meal and also not with thermal bag.

Microwaeable thermoses

These types of thermos have advantage that meal can be heated in the morning directly in MW oven (rather than transferring from cooking pot) and can be carried to the office/educational centers. I got four of these models, Aladdin from USA, ASIAN from India, Double layer lunch box from China, and again Aladdin Magic from USA. I will inform the results of only two of these.

Aladdin Micro Waveable (USA) Thermos, Plastic no. 7, capacity 295 ml. Photo 5.

Photo 5: Microwaveable Aladdin Thermos.

Measurements have been made on Feb. 17, March 8, May 2 and May 3, 2026, however the results are plotted only for March 8, 2026, and is shown in Figure 4.

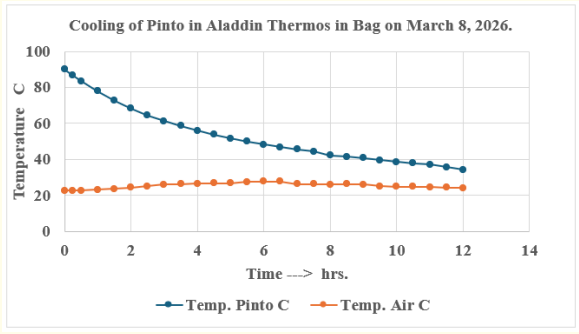

Figure 4: Cooling of Pinto in Aladdin Thermos on March 8, 2026 with thermal bag.

Again, meal temperatures on March 8, 2026, are 90, 55.9, and 51.7 ℃, initially and after 4 and 5 hours respectively with thermal bag, whereas on May 3, 2026, are 90, 50.3 and 45.7 ℃ initially and after 4 and 5 hrs. respectively without thermal bag. Again we can see the advantage of about 6 ℃, using thermal bag.

Stainless Steel Double Layer Lunch Box, 1.1 l, Made in China, Microwaveable, PP, Temp. -20℃ to +100 ℃. Photo 6.

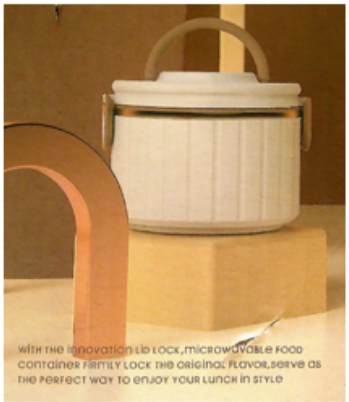

Photo 6: Stainless Steel Double Layer Lunch Box.

On May 12, 2026, 250g of heated pinto was put in this lunch box, which was kept in thermal bag. The pinto and ambiente temperatures was maeasured every hour and data are shown in Figure 5.

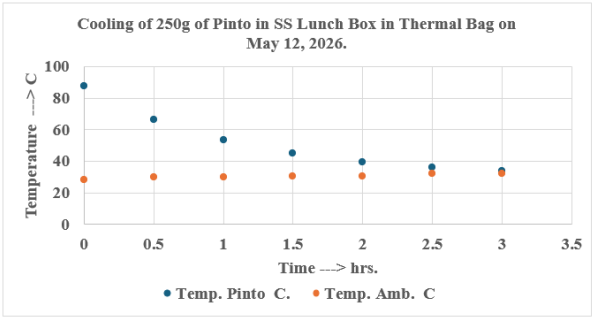

Figure 5: Cooling of 250g of pinto in SS lunch box in thermal bag, on May 12, 2026.

In summary, the meal temperatures on May 12, 2026 was 87.8 (initial), 53.2 (1 hr), 39.6 (2 hrs.) and 33.9 ℃, after 3 hours, without bag and was 90.0 (initial), 64.7 (1 hr), 40.8 (2 hrs.) and 33.8 ℃ after 3 hrs. with thermal bag. Thus as compared to all thermos, this pot is not a good choice for maintaing meal temperature hot even after 3 hours and even with thermal bag. Fortunately, this pot as indicated in the pot, resist temperature from -20 to +100 ℃, has another benefit compared to all other thermoses studied. It can be used in Solar Oven for heating and cooking meal, as well can be used in the Microwave oven, in case the food is not sufficient hot.

Calculation of heat loss coefficient

If inside meal cools fom T_i to T_f in time Δt , then the heat lost, Q is:

$$Q = \frac{m\,C\,(T_i - T_f)}{\Delta t} \quad (1)$$

Where:

- m= mass of water/ meal (kg)
- C= specific heat of water/meal, (J/ Kg ℃)
- T_i= initial water/meal temperature (℃)
- T_f= final water/meal temperature (℃)
- Δt= time duration (s)

This gives the heatloss rate, Q in watts.

Now we can estimate the effective thermal conductivity of a Thermos wall, assuming only heat is conducted through conduction. According to literature, the thermal conductivity will be :

$$\boxed{k = \frac{Q\,L}{A\,(T_i - T_a)}} \quad (2)$$

- k= effective thermal conductivity of the insulation
- A= surface area (m^2) of the Thermos wall (2X 3.14X rX h)
- L= wall thickness (m)
- r is radius of thermos (m)
- h is height of thermos (m)

T_a = ambient temp. (℃)

Formula 2 is not used to calculate thermal conductivity of Thermos with thermal bag.

The heat capacity (Specific Heat) of water is 1 KCal/Kg°C (4200 J/Kg.°C). However in all thermoses (except Buba) I have used rice, beans, onions, coriander, tomatoes etc. Typically heat capacity of meal is close to water but slightly lower. This is because cooked foods are mostly water (60–80%), with the rest being starch, fiber, protein etc., which reduce specific heat. Here I used effective heat capacity of about 3300 J/kg·°C [7]. Using Equation 1, and the temperature of meal measured with time, I have calculated heat lost factor U, for all thermos and are shown in Table 1.

Conclusion

With the objective of getting hot meals at educational centers and offices etc. at lunch time, in addition to the use of Microwave ovens and Solar ovens, one can use Microwaveable (preferably) Thermos bottles for meals. I have studied some thermos bottles, for carrying hot meal (better 90 °C or more) from home. Studied the meal temperature variation with and without thermal bag, to see their effectiveness. Some important/practical results are reported. Table shows the temperatures of 250 g of meal, initially at home, then after 5 hours in various thermoses without thermal bag. In Four thermoses, 250g of Pinto was used. Whereas in Thermos Buba cooling of 1 l of water was studied. On May 30, Earthy and SS Lunch Box were studied also with 0.5 l of water. Heat loss Q and Thermal conductivity, k are calculated in each case.

					Qtnb (W)	k (W/m°C)
Earthy	No Bag	Feb. 20, 2026	87.8 (0 hr.)	40.1 (1 hrs.)	2.18	0.0041
Earthy	With 0.25l of Water	30/5/2026	83.1 (0 hr.)	49.5 (5 hrs.)	2.67	0.0048
Thermo Flask	No Bag	24/2/2026	88.6 (0 hr.)	44.5 (5 hrs.)	1.98	0.021
Buba	No bag (1 l of water)	2/3/2026	85.8 (0 hr.)	66.8 (5 hrs.)	3.5	0.013
Aladdin	No Bag	3/5/2026	90 (0 hr.)	45.7 (5 hrs.)	2.03	0.016
SS Lunch Box	No bag	12/5/26	87.8 (0 hr.)	39.6 (2 hrs.)	5.52	0.024
SS Lunch Box	With 0.25l of water	30/5/2026	86.8 (0 hr.)	39.9 (1.5 hrs.)	9.12	0.016
Qtnb is the Heat loss of Thermos, NO bag.						

Table 1: Performance of some thermos with temperature at different hours (°C) and heat loss coefficient.

One can see that all the thermos studied could give hot lunch after 5 hours, starting from home. Thermos BUBA could provide hot lunch even after 15-20 hours, Best Thermos but not practical for meal due to size. On the other side, one thermos (SS Lunch Thermos), least effective could not provide hot lunch even after 2 hours. Although it is bought recently in Costa Rican shop and comparatively at low price, fortunately has another advantage. It can be used both for Microwave as well Solar oven for cooking and heating.

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