

Animal feed solar cooker:

Design and economics

Surendra Poonia, N K Jat* and C M Ola

ICAR-Central Arid Zone Research Institute, Jodhpur, Rajasthan 342 003

The farming systems in arid western Rajasthan are largely livestock based. The feed concentrates are essential to maintain health and milk production of the mulching animals in particular. For boiling of animal feed, huge amounts of firewood, animal dung cake and other organic wastes are burnt which make it costly, time consuming and unhealthy practice of livestock rearing. In this regard, the abundantly available solar radiation in the region can be utilized for boiling animal feed. Therefore, a low-cost high capacity solar cooker was designed for boiling animal feed using solar energy. The solar cooker was found suitable for boiling 10 kg animal feed per day, which is sufficient for 5 cattle and its efficiency was observed to be 26.4%. This solar cooker was found to save around 91 man-days/year of farm women and 1059 kg of fuel wood/year which is equivalent to 3611 MJ of energy besides saving firewood and animal dung cake for alternative usages. Hence, the animal feed preparation through solar cooker not only reduces greenhouse gas emissions but also helps in fuel conservation and drudgery reduction. Moreover, the use of the solar cooker for animal feed would result in the reduction of the release of 1442.64 kg of CO₂ savings/year.

Keywords: Animal feed, Livestock, Solar cooker

Livestock contributes a major portion of the income of farmers due to the sale of milk and meat of small ruminants, besides providing gainful employment and manure for crop production. For higher milk productivity and to maintain animal health, mostly farmers feed the mulching animals like cow and buffalo with feed concentrates during milking period. Farmers in arid western Rajasthan generally boil the animal feed concentrates daily for improvement in digestibility and nutritional quality of the feed. The common fuels for boiling animal feed are firewood, cow dung cake and agricultural wastes. These biomasses based resources are already scarce in arid regions and have alternative uses as source of nutrients in soil through manuring. Use of these biomass fuels involve drudgery, time consuming, costly and pollute environment through carbon emission besides affecting health of farmwomen. Considering

these, a transition towards alternative energy sources for cooking purpose was felt. Therefore, utilization of solar energy may be a promising option as it is abundantly available throughout the year in most parts of the country. Most parts of the country receive 4.0 to 6.3 kWh/m²/day solar irradiance during November to February while in summer it varies from 5.0 to 7.4 kWh/m²/day. The arid and semi-arid regions of the country like western Rajasthan receive much more radiation as compared to rest of the country. In western Rajasthan, the mean annual daily solar radiation amounts to 6.0 kWh/m²/day having average sunshine of 8.9 hours/day. Therefore, solar cooking could be most suitable option to prepare animal feed. Moreover, drudgery and time involved in conventional boiling process can also be avoided in solar cooking and it also saves firewood and thus can save considerable time which can be

utilized to perform extra agricultural activities.

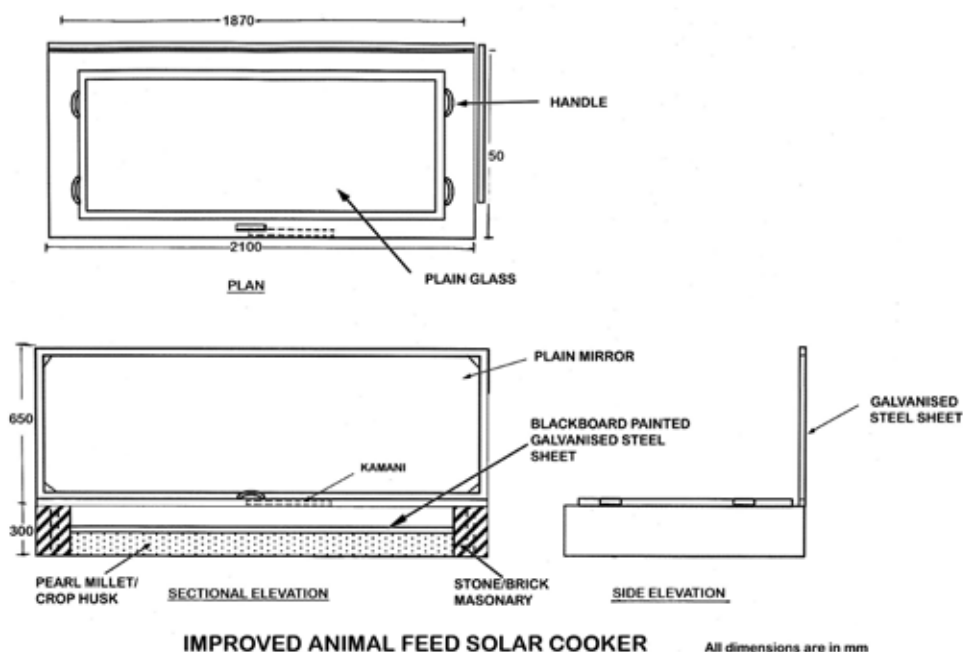
The baseline survey of ICAR-CAZRI Farmer-FIRST Project villages revealed that farmers are using traditional cook-stove (Chulha) which has about 10% thermal efficiency for boiling animal feed and consumes around 6.0 kg of firewood for boiling 10 kg of feed concentrates. Under ICAR Farmer FIRST project, a total of 5 units of animal feed solar cookers, fabricated and evaluated at ICAR-CAZRI, Jodhpur were provided in farmer participatory mode and installed at Beru village in Jodhpur district of Rajasthan.

Design of improved animal feed solar cooker

The commercially available box-type solar cookers have low capacity and need to be oriented towards the sun frequently. Considering this, an improved low-cost animal feed solar cooker was designed, developed,

and tested at ICAR-CAZRI, Jodhpur. The design was based on the concept of a non-tracking solar cooker by designing a length-width ratio of more than 3:1, so that maximum amount of radiation could be received which fell on the glass cover throughout the day. The solar cooker was installed in a Pucca open space avoiding any shade effect at any time of the day. This improved solar cooker comprised of a pit of brick wall (0.1 m) plastered with cement-sand in a ratio of 1:6. The outer and inner dimensions of the solar cooker were kept 1980 mm length $\times$ 760 mm width $\times$ 100 mm depth (length in East-West and width in North-South direction) and 1870 mm $\times$ 650 mm $\times$ 50 mm, respectively. The bottom of the solar cooker was also brick-plastered (sand-cement 6:1) for insulation from the ground. The depth of the cooker was kept 300 mm, half of which was filled with pearl millet hull to provide 150 mm insulation from the bottom.

A 24-SWG galvanized steel sheet painted with black board paint on the upper side was placed above the pearl millet hull layer as a heat insulator. Besides the insulator plate, the plastered inner layer of solar cooker and outer layer of the cooking pot were also painted with black board paint for better absorption of heat generated inside the pit. The height of cooking pots from insulator sheet was kept at 100 mm, and about 50 mm depth was maintained between the top of the cooking pots and the glass sheet. These dimensions of solar cooker could accommodate three aluminium cooking pots of 550 mm $\times$ 450 mm $\times$ 100 mm with lids for boiling of 10 kg animal feed material. The solar cooker pit was covered with two horizontal glass covers (4 mm thickness each) fixed on a removable aluminium-wooden frame. The spacing between the two glass covers was maintained at 15 mm to create air insulation to avoid temperature losses from



Improved low-cost animal feed solar cooker designed by CAZRI, Jodhpur

glass surface. The dead weight of this double-glazed frame of the solar cooker remains around 25 kg. A rubber seal of appropriate size was placed between the contact surfaces of the brick wall and a cover glass frame was placed to make the cooker pit air-tight to avoid heat losses. The radiation intensity for further boosting the temperature of the solar cooker pit was increased by vertically placing one plane mirror (4 mm thick) reflector in aluminium angle and wooden frame attached to the north wall of the solar cooker.

Performance evaluation at farmers' field

The performance evaluation of the animal feed solar cooker was carried out at farmers' field during clear sky conditions in April 2022. The performance of solar cooker was tested for boiling animal feed as per existing testing standards. Animal feed ingredients, viz. crushed, barley (Jau Ghat), guar korma, gram churi, cotton seed, and oil cake were successfully boiled between 9:00 AM and 3:00 PM. About 10 kg of animal feed can be boiled in a single animal feed solar cooker per day. There is a 15°C rise in temperature in the animal feed solar cooker with a reflector as compared to without reflector. The stagnation temperature recording of the empty solar cooker was started

at 10:00 AM. The insulation sheet temperature increased up to 100°C within half an hour and stagnated at about 140°C at around 1:00 PM. Based on temperature recordings, the values of first figure of merit (F_1), second figure of merit (F_2), and standardized cooking power (P_s) estimated were 0.120, 0.424, and 45W, respectively which categorized the cooker as class 'A'. The overall efficiency of the animal-feed solar cooker was 26.5% (Table 1). The performance of the cooker was excellent during summer, however with the aid of a reflector mirror its efficiency can be improved for winter months also.

Table 1. Performance indicators of animal feed solar cooker

Particular	Value
Ambient temperature	37.0°C
Inside temperature without reflector	92.4°C
Inside temperature with reflector	107.6°C
Stagnation temperature	140°C
First figure of merit (F_1)	0.120
Second figure of merit (F_2)	0.424
Standardized cooking power (P_s)	45 W
Overall efficiency	26.5%

Advantage and economics

As estimated (Table 2), the animal feed solar cooker with improved design is easy to fabricate at village

Table 2. Material cost of animal feed solar cooker unit

Material	Approximate cost (₹)
Brick wall pit	500
Bricks (100 @ ₹5/brick)	
Cement (1 bag)	400
Sand (3 bags)	50
Labour (1 man day)	700
Pearl millet grain hull (2 kg)	-
G.I. Sheet (22 gauge) (1865 × 480)	500
Black board paint (500 ml)	450
Palin glass sheet [2 (1980 mm × 760 mm, 4 mm thick)]	3000
Fabrication cost of double glass cover	900
Mirror [1 (1980 mm × 680 mm, 4 mm thickness)]	1200
Fabrication charges of mirror frame	900
Rubber gasket (25 mm wide) (5.1 m)	400
Total cost	9000

Table 3. Estimated cost and benefits of animal feed solar cooker

Particular	Value
Cost of animal feed solar cooker	₹9000/unit
Capacity	10 kg/day for 5 milch animals (feed ready by 3:00 PM)
Operating and maintenance cost	Negligible
Expected life	~10 years
Rationalized cost/year	₹900
Firewood saved	~1000 kg/year
Cost of firewood saved	~ ₹2000/year
Time saved (Estimated) (2 hours/day)	~ 91 man-days
Saving of GHG emission	~ 1442.64 kg of CO ₂ /year
Health benefits	Reduced smoke inhalation and respiratory diseases



Installed solar cooker



Solar cooker in operation



Boiled animal feed



Animal feeding on boiled feed

level at a cost of about ₹9000/unit to boil around 10 kg of feed for 4-5 animals (Table 3). Boiling animal feed through solar cooker saves around 1.0 tonne (3 kg/day) of firewood costing about ₹2000. Besides its easy operation, it saves around 2 hours daily which amounts to 91 man-days a year. Animal feed boiling is done mostly by farm-women, thus in saved time they can contribute significantly to family care or other agricultural operations. Meanwhile, due to avoidance of exposure to smoke, the health status of farm-women can also be improved, if used on a regular basis. Moreover, the use of the solar cooker for animal feed would replace the firewood (~1000 kg/year) which amounts to a reduction of 1442.64 kg CO₂/year to the environment (Table 3). Conservation of firewood helps in preserving the ecosystem and animal dung cake could be used as manure for crop production.

SUMMARY

The drudgery involved, time and health issues related to boiling of animal feed with conventional fuels warrant alternative means of animal feed cooking. Considering the abundance of sunshine in most parts of India, boiling animal feed using solar energy is found as a suitable alternative. Animal feed solar cooker was designed in such a way that it is easy to fabricate at the village level with the help of a carpenter. The use of animal-feed solar cooker helps in the saving of conventional domestic fuels such as firewood, cow dung cake and agricultural waste in rural areas. The use of animal-feed solar cooker would result in saving time and drudgery of farm-women. Moreover, the use of these devices would result in the reduction of the release of CO₂ into the environment and getting Certified Emission Reduction (CER) under the Clean Development Mechanism (CDM) of the United National Frame Work Convention on Climate Change (UNFCCC).

*Corresponding author's e-mail:
nandagro09@gmail.com