ISSN Print: 2664-844X
ISSN Online: 2664-8458
IJAFS 2025; 7(2): 227-230
www.agriculturaljournals.com
Received: 05-01-2025
Accepted: 06-02-2025

Sunita Kumari
Ph.D Scholar, Department of Family Resource Management, CCS Haryana Agricultural University, Hisar, Haryana, India

Savita Singal
Professor, Department of Family Resource Management, CCS Haryana Agricultural University, Hisar, Haryana, India

Corresponding Author:
Sunita Kumari
Ph.D Scholar, Department of Family Resource Management, CCS Haryana Agricultural University, Hisar, Haryana, India

Transforming Biomass into sustainable fuel for rural households in Haryana

Sunita Kumari and Savita Singal

DOI: https://doi.org/10.33545/2664844X.2025.v7.i2d.299

Abstract
India being an agricultural country has a huge potential of biomass in the form of crop residues. It is also produced as a by-product in many agro based industries. Rural households in India are almost entirely reliant on loose biomass viz. agricultural residues, animal dung and wood for their basic cooking fuel needs. Direct burning of loose biomass fuel in chulha is associated with very low thermal efficiency and widespread air pollution which causes serious health problems like difficulty in breathing, irritation in eyes, chronic respiratory diseases and headache because of smoke from these smoke particulates. It also leads to a large number of premature annual deaths among pregnant women. Based on this rationale, an exploratory research was carried out to study the existing fuel use pattern and to introduce biomass pellets and pellet stoves in rural households of Hisar district. More than half of the respondents had nuclear type family (58.18%), belonged to young age group (54.54%), were illiterate (51.81%) and had farming as main occupation (55.45%). Families also had low family education status (38.18%). Cent per cent respondents used traditional chulha and crop residues for cooking activity. A vast majority of respondents were responsible for fuel collection (74.54%) and carried it on head (87.27%). Respondent made 5-7 trips/week (68.18%), collected 16-20kg biomass/trip (61.81%), spent 3-4hrs/trip (59.09%), and for fuel collection covered 5-7 km distance per trip (47.27%). They used 6-8 kg biomass/day (56.36%). In phase II, training on use of biomass pellet stoves was imparted to 110 respondents selected purposively, depending upon their willingness and participate. Cent per cent respondents perceived it as beneficial as it was smoke free and there was no blackening of utensils, clothes and walls (88.18%). Ash content was much lower and there was no mess around the stove after using it. A vast majority of respondents also found it simple to use, easy to store, and easy to move from one place to another. Maximum respondents used pellet stove for water boiling (90.00%), chapati making (89.09%), milk boiling (80.90%), and daal preparation (68.18%). A small percentage of respondents also used it for vegetable preparation (26.36%), tea preparation (10.90%) and parantha making (7.27%). Majority (88.18%) of the respondents used ½ kg pellets at a time. Maximum respondents reported that pellet stove took 10-15 minutes to ignite in the beginning and ½ kg of pellets burnt for 45 minutes, once the stove is ignited. The findings of this exploratory research work can have important implications both for the policy makers as well as field functionaries. Mass media can also play an important role in propagating the use of clean green fuel from biomass.

Keywords: Clean fuel, biomass pellets, biomass pellet stove, use pattern

Introduction
India is mainly an agricultural country. Therefore, it has a huge potential of biomass in the form of crop residues like rice straw, cotton stalks, coffee husk, coir pith, jute sticks, groundnut shells, mustard stalks, forest leaves etc. Biomass is also produced as a byproduct in many agro based industries such as rice husk from rice mill, saw dust from saw mill, bagasse from sugar mills etc. Over 370 million tonnes of biomass are generated every year (Chauhan, 2010) [1]. Rural households in India are almost entirely reliant on traditional biomass viz. agricultural residues, animal dung and fuel- wood for their basic cooking energy needs. ESMAP (2002) reported that most rural villagers still depend predominantly on traditional fuels to meet their modest energy needs viz., fuel-wood, crop wood, crop wastes, and dung for cooking and heating, along with access to modern fuels. Direct burning of loose biomass in conventional stove is associated with very low thermal efficiency and widespread air pollution. Use of loose biomass and wood is also estimated to cause serious health problems like difficulty in breathing, irritation in eyes, chronic respiratory diseases and headache because of smoke from these smoke particulates.

It also leads to a large number of premature annual deaths among pregnant women. Ramchandra *et al*. (2000), Rajvanshi (2003), Indra *et al*. (2007) [6, 5] also concluded that the major cooking energy source is biomass in rural areas of India. It is used in extremely inefficient (10-15% efficiency) and smoky cook stoves or *chulhas* which are constructed mostly by house wives themselves. Besides inefficiency, the present biomass cook stoves (*chulhas*) increase the household pollution and are hazardous to the health of housewife. Joon *et al*. (2009) [4] reported that there was more availability and utilization of solid biomass fuels as energy resources in domestic sector as compared to the commercial fuels. Dung cakes, crop residues and firewood were found to be the three main fuels used for cooking, though LPG was also used along with these biomass fuels. It was further pointed out that the households have not switched over completely to cleaner fuels in spite of the fact that they have been using LPG for many years.

Therefore, in Indian households, energy problem is not primarily a problem of the scarcity of energy, but inefficient combustion and smoke related health problems. Briquetting and pelletizing is an appropriate technology for harnessing renewable energy from this huge available stock of biomass. Conversion of biomass into pellets can help to overcome the problem of inefficient combustion besides mitigating the health problems of women and children associated with smoke pollution. Thus, improving access to this affordable clean, green, and smoke free energy is critical for improving the quality of life in rural areas. Use of biomass energy shall ultimately result in improving the health and the environment. In view of the above, the present exploratory research was carried to introduce biomass pellets and pellet stoves in rural households. Specific objectives of the study were:

1. To collect baseline data on existing fuel use pattern in rural households of Haryana.
2. To impart training to rural women on use of biomass pellets and pellet stoves.
3. To delineate benefits and constraints perceived by rural women in use of pellet stoves.

Methodology

The present study was conducted in a randomly selected village of Hisar district in Haryana, a north-west agrarian state of India. To select the sample, demonstrations on the use of biomass pellets in improved pellet stoves were arranged for all interested rural households. Based on their interest and willingness to participate in research, a sample of 110 rural households who were using traditional wood stove for cooking and were interested in use of pellet stove, was selected purposively. Active female head of the household was selected as the respondent. Thus, the total sample for the research comprised of 110 rural women. Baseline data on fuel use pattern were collected personally by the researcher with the help of a structured interview schedule which had been duly pretested and finalized. Selected respondents were imparted training in use of improved biomass pellet stoves. One biomass pellet stove and 2 kilograms of biomass pellets were provided to every respondent for cooking and heating activities for 3 days. The collected data, were suitably analyzed with the help of appropriate statistical methods i.e., frequencies, percentages and weighted mean scores.

Results and Discussion

The findings have been discussed under the following heads

- Background profile of the respondents
- Existing fuel use pattern in rural households
- Use pattern of improved pellet stoves

Background Profile of Respondents

Perusal of table 1 reveals that more than half of the respondents (54.54%) belonged to young age group (18-26 years), followed by 34.54 per cent in middle age group (27-35 years) and remaining 9.09 per cent respondents in old age group (36-44 years). Respondents (46.36%) belonged to lower caste, followed by middle caste (43.63%) and high caste (10.00%). A little more than half of the respondents (51.81%) were illiterate, whereas 40.90 per cent respondents were educated up to primary level and only 7.27 per cent of respondents had education up to middle class. Family education status was found to be low, middle and high for 38.18, 35.45 and 26.36 per cent respondents, respectively. Majority of the respondents (58.18%) had nuclear type family whereas remaining 41.81 per cent respondents belonged to joint family. Main occupation of the family was farming (55.45%), followed by landless labour (35.45%), service (5.45%) and business (3.63%), respectively.

Table 1: Background profile of the respondents (n=110)

Sr. No.	Parameters	Frequency	Percentage
1.	**Age**		
	18-26 yrs	60	54.54
	27-35 yrs	38	34.54
	36-44 yrs	12	9.09
2.	**Caste**		
	Lower	51	46.36
	Middle	48	43.63
	High	11	10.00
3.	**Education of the respondent**		
	Illiterate	57	51.81
	Primary	45	40.90
	Middle	8	7.27
4.	**Family Education Status**		
	Low (<2.0)	42	38.18
	Medium (2.0-4.0)	39	35.45
	High (>4.0)	29	26.36
5.	**Type of family**		
	Nuclear	64	58.18
	Joint	46	41.81
6.	**Occupation of head of the family**		
	Farming	61	55.45
	Landless labour	39	35.45
	Business	4	3.63
	Service	6	5.45

Existing fuel use pattern for cooking

Cent per cent respondents were using traditional *chulha* which indicates their dependency on traditional biomass fuel for cooking (Table 2). Only 22.72 and 27.27 per cent respondents were also using LPG stove and kerosene stove, respectively, while a negligible percentage of respondents (6.36%) used electric heater for cooking or heating purposes. Table 2 further depicts that cent per cent respondents were using crop residues (rank-I), followed by fuel wood (70.00%, rank-II), cow dung cake (63.63%, rank-III) and LPG stove (12.72%, rank-IV).

It is clear from the data that a huge majority of respondents were not using commercial sources for cooking electric heater-93.63%, LPG stove -77.27%, and kerosene stove - 63.63%, rank-VI.

Table 2: Existing fuel use pattern in rural households (n=110)

Sr. No.	Cooking stove and Fuel use pattern	Frequency	Percentage
1.	**Cooking stove used***		
	Traditional chulha	110	100
	Kerosene stove	30	27.27
	LPG stove	25	22.72
	Electric heater	7	6.36
2.	**Fuel use pattern**		
	Fuel wood A	77	70.00
	S	30	27.27
	R	3	2.72
	N	-	-
3.	**WMS 2.67 (II)**		
	Crop residues A	110	100
	S	-	-
	R	-	-
	N	-	-
4.	**WMS 3.00 (I)**		
	Dung Cake A	70	63.63
	S	24	21.81
	R	7	6.36
	N	9	8.18
5.	**WMS 2.40 (III)**		
	Kerosene stove A	-	-
	S	11	10
	R	19	17.27
	N	70	63.63
6.	**WMS 0.27 (V)**		
	LPG stove A	14	12.72
	S	8	7.27
	R	3	2.72
	N	85	72.27
7.	**WMS 0.55 (IV)**		
	Electric Heater A	-	-
	S	3	2.72
	R	4	3.63
	N	103	93.63
WMS 0.09 (VI)			

***** Multiple response. A- Always, S- Sometimes, R- Rarely, N- Never. WMS- Weighted Mean Score. Figures in parenthesis indicate Rank

Mode of fuel collection by rural women

Mode of fuel collection by rural women is presented in Table 3. The data clearly indicates that more than half of the respondents (56.36%) were using 6-8 kg biomass/day, while 30.90 per cent respondents were even using 9-11 kg biomass per day respectively. It is further evident that more than two-third respondents (68.18%) were making 5-7 trips per week for collection of biomass fuel, while one fourth of the total respondents made 3-4 trips in a week. Majority of respondents (61.81%) carried 16-20 kg biomass per trip, followed by 24.54 per cent respondents carrying 10-15 kg of biomass. In terms of total distance covered for fuel collection, it is evident from Table 3 that slightly less than fifty per cent of the respondents (47.27%) covered 5-7 kms of distance per trip, followed by a distance upto 4 kms (33.63%).

Table 3: Mode of fuel collection by rural women (n=110)

Sr. No.	Parameters	Frequency	Percentage
1.	**Biomass fuel used/day (kg)**		
	3-5	14	12.72
	6-8	62	56.36
	9-11	34	30.90
2.	**No. of trips/week**		
	1-2	8	7.27
	3-4	27	24.54
	5-7	75	68.18
3.	**Biomass collected/trip (kg)**		
	10-15	27	24.54
	16-20	68	61.81
	21-25	15	13.63
4.	**Total distance walked to collect biomass fuel (km)**		
	Upto 4	37	33.63
	5-7	52	47.27
	8-10	81	19.09
5.	**Time spent/trip (hrs.)**		
	1-2	33	30.00
	3-4	65	59.09
	5-6	12	10.90
6.	**Medium of transport**		
	Head	96	87.27
	Bicycle	6	5.45
	Bullock cart	5	4.54
	Trolley	3	2.72
7.	**Person responsible for fuel collection**		
	Respondent	82	74.54
	Husband	3	2.72
	Adult male children	5	4.54
	Adult female children	20	18.18
	Minor children	-	-

kg- kilogram, km- kilometer, hrs.- hours

Nearly twenty per cent respondents even covered 8-10 kms of distance per trip for collection of fuel. The time spent for fuel collection shows that majority of respondents (59.09%) spent 3-4 hrs, while 30.00 per cent respondents spent 1-2 hrs. Only 10.90 per cent respondents spent 5-6 hrs per trip on fuel collection. Biomass fuel was carried as a head load by 87.27 per cent respondents while others carried it on bicycle (5.45%), bullock cart (7.26%). Majority of the respondents (74.54%) shouldered the responsibility for fuel collection, followed by adult female children (18.18%), and other members (7.26%).

Use pattern of biomass pellet stoves

Use pattern of improved pellet stoves included quantity of pellets used, time duration for which the stove burnt continuously at a time, and the type of foods cooked by respondents (Table 4). Scrutiny of Table 4 reveals the use pattern of biomass pellet stove. Maximum respondents used ½ kg pellets at a time (88.18%) and reported that the stove took up to 15minutes to ignite (80.00%). Remaining twenty per cent respondents reported that the stove took longer to ignite (anywhere between 16-30 minutes). For a vast majority of respondents, ½ kg pellets burnt continuously for 45 minutes (74.22%), or 60 minutes (14.89%). With 3/4 kg of pellets, the stove kept ignited for 1.25 hours (30.76%) to 1.50 hours (46.15%).

Table 4: Use pattern of biomass pellet stoves in rural households

Sr. No.	Parameters	Frequency	Percentage
1.	**Quantity of pellets used at a time (n=110)**		
	½ kg	97	88.18
	1 kg	13	11.81
2.	**Time taken to ignite the stove(n=110)**		
	5-10 min.	10	30.00
	11-15 min.	33	50.00
	16-20 min.	55	10.90
	21-30 min.	12	9.09
3.	**Stove burnt with ½ kg pellets for (n=97)**		
	Upto 30 min.	11	11.33
	Upto 45 min.	72	74.34
	Upto 60 min.	14	14. 33
4.	**Stove burnt with 3/4 kg pellets for (n=13)**		
	Upto 60 min.	3	23.09
	1 hr 15 min.	4	30.76
	1 hr. 30 min.	6	46.15
5.	**Food items prepared (n=110)**		
	Water boiling	99	90.00
	Chapati making	98	89.09
	Milk boiling	89	80.09
	Daal preparation	75	68.18
	Vegetable preparation	29	26.36
	Tea preparation	12	10.90
	Parantha making	8	7.27

Kg. - Kilogram; min. – minutes

Further, as high as ninety per cent respondents used pellet stove for water boiling and *chapatti* making while nearly seventy percent respondents used it for *daal* preparation (68.18%). Approximately one-fourth of the respondents also used the improved stove for vegetable preparation (26.36%). Only a negligible percentage of respondents used this stove for making tea (10.90%) or *paranthas* (7.27%).

Summary and Conclusion

All respondents used traditional *chulha* for cooking activity. Fuel wood, crop residues and cow dung cakes were the main fuels used by them. Respondents carried 16-20 kg biomass per trip and covered 5-7km distance per trip. Biomass fuel was carried as a headload which is very injurious for their back and neck. After the training on use of biomass pellet stoves, respondents preferred to use ½ kg of biomass pellets at a time as the stove kept ignited for about 45 minutes. It was used mainly for boiling milk, preparing *daal* and making *chapaties*. The findings, on the whole, reflect that there is a vast scope of using this clean and green energy from biomass at household level. Government of India should promote the utilization of this renewable and clean green energy to the maximum possible extent at household level by establishing end-user markets on a massive scale for sustainable development. Field functionaries and mass media can also play an important role in this direction.

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