RESEARCH ARTICLE

SOCIO-ECONOMIC IMPACT OF MULTIPLE FURNACE OVER SINGLE FURNACE IN JAGGERY PREPARATION

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Abstract

Sugarcane is an important cash crop occupying a prime place in Indian agriculture. Though it is mainly grown for production of white sugar in India, *gur* (jaggery) and *khandasari* (brown sugar), two other important sweetening agents from sugarcane, utilize about 45% of the cane produced. Jaggery preparation is the largest agroprocessing industry in the Cauvery command area of Karnataka (South Karnataka) comprising the entire Mandya and Chamrajanagar districts, parts of Mysore, Tumkur and Hassan districts with more than 3000 jaggery making units. A survey based study of jaggery making units in this area especially in Mandya and Chamrajanagar district was undertaken to know the performance of multiple furnace over traditional furnace in jaggery preparation in economic terms. Type of furnace was found to be the main deciding factor on quickness and efficiency of sugarcane juice boiling and jaggery preparation. The local types, viz. single pan and double pan furnaces not only consumed more time but were also uneconomical in terms of output and thereby net income. The jaggery output of those who have adopted triple pan furnace was twice that of local types. The impact of multiple pan furnace was in terms of economy, time saving, labour use, more production, productivity and efficiency of jaggery unit operation than the local types.

Key words: Sugarcane, jaggery, furnace, constraints, economics

Introduction

Sugarcane is an important cash crop occupying a prime place in many tropical and sub-tropical countries. Although it is mainly grown for production of white sugar in India, other sweetening agents such as *gur* (jaggery) and *khandasari* (brown sugar) utilize about 45% of the cane produced (Joshi, 2015). Jaggery and *khandasari* cottage industry provides employment to 2.5 million people in rural India with production statistics of 8 million tonnes and 2 million tonnes, respectively (*APEDA 2009).*

Jaggery preparation is the largest agro processing industry in the Cauvery command area of Karnataka (South Karnataka) comprising the entire Mandya and Chamrajanagar districts, parts of Mysore, Tumkur and Hassan districts with more than 3000 jaggery making units. Bucket jaggery is very common in Mandya region which has great demand in Gujarat, Maharashtra and West Bengal states, and also in neighbouring countries (Parashuramappa and Devaraj 2000). Cauvery command area contributes the lion's share of total sugarcane area in Karnataka where nearly 50% of cane produced is being used for making jaggery. Also, Cauvery command area is unique in the sense that the peak jaggery making season (May to November) is off season for the rest of jaggery making in the country (Baboo and Solomon 1995).

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Jaggery is a traditional sweetener which is produced in addition to sugar from sugarcane (Nagarajan et al. 1985; Hunsigi, 2001). It is produced by boiling sugarcane juice in small jaggery making plant to solid jaggery, which contains 65-85% sucrose (Rao et al. 2007). It contains iron (11%), calcium (0.4%), phosphorous (0.045%), glucose and fructose (10-15%), protein (0.25%) and fat (0.05%) (Kumar, 1999).

Jaggery making process involves four main steps viz., extraction of juice from the cane using a three roller power crusher, clarification of juice, concentration of juice to semi-solid state and moulding to different shapes from 20 g pellets to 10 kg buckets. The type of furnace is important in deciding the quickness and efficiency of juice boiling. Besides other factors, quickness in boiling has got a direct impact on the per day jaggery production rate. The efficiency of furnace indicates the amount of heat generated for juice boiling per unit of fuel consumption. It is possible to increase the efficiency of heat utilization by about 10% which would save 0.7 tonnes bagasse (Baboo and Solomon 1995). The main criterion for choosing the type of furnace by the farmers of Cauvery command area is quickness in boiling vis-à-vis per day jaggery production rate.

Jaggery producers use single, double and triple pan furnaces for jaggery making in this region. Though almost half of the cane produced is used for jaggery and jaggery units are quite often competitive to sugar industry, much study has not been conducted on the socio-economic aspects and operational efficiency of jaggery units. In view of the above facts, a study was undertaken to evaluate the production and operational levels of jaggery units with different types of furnaces.

Materials and methods

The study was conducted in Pandavapura, Srirangapatna and K.R. Pet taluks of Mandya district in Karnataka, South India, which is predominant with over 1000 jaggery units. Mandya district is a traditional jaggery making area owing to its suitability for growing sugarcane (~ 65,000 ha) due to loamy soil, adequate good quality water source from the river Cauvery and a temperature range of 28-34^{0}C. In the descriptive type of research design applying ex post facto approach adopted for the study, 36 cane growers, comprising 12 each representing single, double and triple pan furnace adopters in their jaggery units, were selected at random. An interview schedule was developed for this purpose and pilot tested with non-sample farmers. Detailed survey was undertaken by personal interview using the pre-tested interview schedule. The yield data on jaggery was recorded from the individual units and the sociological appraisal was done through personal interview. Their responses were tabulated and the data were analyzed using mean, and simple percentage analysis as the statistical tools.

Results and discussion

The present study focused on the profile of jaggery farmers, comparative analysis of jaggery units based on the furnace used, economics involved and constraints in jaggery making. The results are presented and discussed below:

Demographic profile of farmers growing sugarcane for jaggery

Age: The age of the household heads ranged from 30 to 80 years, the average being 47.37. Apparently, age is not a constraint in adopting scientific jaggery making technologies.

Education: As per educational level, 11.11% of the farmers were graduates, 61.12% had primary or secondary education and the rest 27.77% were illiterates.

Occupational status: Agriculture was being practiced as primary occupation by 63.88% and as secondary occupation by 36.12% respondents. The other occupations included business, poultry, saw mill, rearing milch animals, vegetable production, producing vermicompost, etc.

Family type and size: About 63.88% of the respondents lived in joint families and the rest in nuclear families. The family size was 4-6 in 55.54% of the families followed by three in 27.77% of the families. Joint family system is obviously advantageous as jaggery making is a collective endeavor.

Farm size: Although land holding ranged 1.80 - 8.50 acres, 66% of the respondents owned a holding of five acres and below.

Material possession: About 75% of the respondents possessed bullock cart and cooper; 44.44% owned tractor and 41.66% maintained sprayers. The other implements possessed are bullock operated seed driller (16.66%), tractor operated rotovator (11.11%) and power tiller (11.11%). Among the respondents, government subsidy was availed of by 11.11% for bullock cart and 19.44% for other implements.

Livestock possession: The respondents owned bullocks (83.33%), milching cows (75%), calves (55.55%), buffaloes (41.66%), goat (19.44%) and sheep (8.33%) for household purpose; only 2.77% had commercial poultry units.

Social participation: The social participation of the respondents was mainly in terms of membership in milk cooperative societies (83.33%), water cooperative societies (19.44%), village panchayats (36.11%), sugar mills (36.11%), taluk panchayats (5.55%) and farmers clubs (2.77%). The medium land holders were found to have high social participation and they had better awareness about rural development activities and other social happenings.

Mass media participation: The mass media channels utilized by the farmers include television (farm programs), radio, newspaper (news related to agriculture, development programs, farmers fair etc) and farm magazines. While only 19.44% of the respondents had access to all the mass media channels, the rest (80.56%) had access to only selected mass media channels. The study indicated that greater mass media participation enhanced the level of adoption of scientific technologies as it helps create awareness about new technologies.

Varieties used for jaggery making

The varieties Co 62175 and Co 86032 were grown by all the respondents in the three categories of pan

Table 1. Varietal usage pattern among cultivators owning different types of jaggery units

Variety	Single Pan		Double Pan		Triple Pan		Total	
	No.	%	No.	%	No.	%	No.	%
Co 62175	12	100	12	100	12	100	36	100
Co 86032	12	100	12	100	12	100	36	100
Co 7804	2	16.67	4	33.33	5	41.67	11	30.55
Co 8371	1	8.33	-	-	-	-	1	2.77
Co 419	10	83.33	3	25.00	-	-	13	36.00

users (Table 1). These varieties possess varietal characters such as soft rind, low fibre, medium girth, low mineral content and high sucrose with low reducing sugars (Thangavelu 2005). Co 62175 was found to be the best variety in terms of quality parameters and jaggery recovery in southern Karnataka (Shivaramu et al. 2002). Three other varieties were used by smaller proportions of respondents.

Comparative analysis of jaggery units

Jaggery plants basically consist of an underground furnace over which sugarcane juice is boiled in large boiling pans. It has been observed that furnaces and chimney of these plants are not properly designed, a large proportion of heat produced is wasted and dense smoke generally billows out of the chimney of these conventional plants; as a result, bagasse consumption is very high in these plants. The process of jaggery making is identical in all parts of the Indian subcontinent but differences exist in the design of plants being used for jaggery making. In the northern Indian states of Uttar Pradesh and Uttarakhand, three-pan jaggery making units are popular whereas in the state of Maharashtra, single pan and four pan plants are popular. It is evident that bagasse can be saved for other applications only when the combustion and thermal efficiency of the jaggery plants are improved. In Karnataka, traditionally jaggery is made in units with single and double pan furnaces; recently, farmers have started using three pan furnaces as well and hence a comparative study of the three types of furnaces was made. In the context to this, comparative analysis was made in terms of type of jaggery unit, quantity of cane crushed, duration of operation, fuel consumption and jaggery produced.

In the study area, it was observed that the conventional three pan jaggery making plant consists of one vertical three roller sugarcane crusher, three mild steel boiling pans of 45-55 cm height and 152-157 cm diameter placed one below another. Ordinary masonry bricks, cement, sand and earth clay are used for its construction. The process of jaggery making in a three pan plant is a continuous process and requires 7-8 skilled laborers. At the start of the process, all the three boiling pans are filled with sugarcane juice and fuel (bagasse) is charged through a charging hole below the lower most boiling pan (Pan No. 3). The maximum temperature of around 1000°C is found below the boiling pan 3. Transfer of heat underneath this boiling pan is mainly through convection and radiation. The other two boiling pans also receive some heat through convection from the hot flue gases moving towards the chimney under a continuous draft. After the sugarcane juice in the boiling pan 3 solidifies by evaporation, the jaggery is cleared from the pan. Later, the second batch of pre-heated sugarcane juice from the middle or boiling pan 2 is released into boiling pan 3, preheated sugarcane juice of boiling pan 1 is let into pan 2 while fresh sugarcane juice is filled in boiling pan 1 through a feeder pipe from the sugarcane crusher.

Ownership of jaggery units with varied power source for crusher

The analysis of ownership of jaggery units on the basis of power source used for crusher (Table 2) indicated that 69.44% of the respondents used both diesel and electric power operated crushing units; 91.67% of the triple pan furnace users and 66.67% of the double pan furnace users opted for both diesel and power operated crushers. On the other hand, about half the single pan users operated with one power source, i.e. only diesel. This implies that most respondents, particularly those using double and triple pans, realized the importance of uninterrupted operation of the jaggery unit and opted for both types of crushers.

Table 2. Pattern of ownership of jaggery units on the basis of power used for crusher

Type of jaggery unit owned	Single Pan		Double Pan		Triple Pan		Total	
	No.	%	No.	%	No.	%	No.	%
Electric power operated crusher alone	-	-	3	25.00	1	8.33	4	11.12
Diesel operated crusher alone	6	50.00	1	8.33	-	-	7	19.44
Both diesel and electric power operated crushers	6	50.00	8	66.67	11	91.67	25	69.44

Quantity of cane crushed

It is evident from Table 3 that the cane crushed by farmers using single pan furnace ranged from 1.0 to 9.0 t/ d with a slightly higher proportion in the 5.0-7.0 range. On the other hand, most farmers using two pan furnace crushed 7.0-9.0 t/d. In triple pan furnace, the range of cane crushed per day was 7.0-9.0 t/day and above with a very high percentage occupying >9.0 t/d slot. When all the respondents were considered together, a higher proportion occupied the > 5 t/d brackets. Obviously, triple pan furnaces facilitated maximization of the volume of cane crushed and quantity of jaggery recovered.

Duration of operation of jaggery units

The duration of crushing ranged from 121 to 301 days depending on the availability of cane and labour (Table 4). Quite often, the excess cane is diverted to sugar factories for crushing. The average crushing days was the highest in triple pan furnace units (270) followed by 265 days in double pan furnace and 209 days in single pan furnace units. Among the single pan furnace users, 50.00% operated the units for 181-210 days followed by 33.33% in the 211-240 days range. Among the double pan furnace users, 41.67% had a crushing duration of 271-300 days followed by 211-240 days (33.33%) and 240-270 days (16.67%). Among the triple pan furnace users, 33.33% users crushed cane for a duration of 240-270 days followed by 25.00% in the 271-300 days slot. Thus, triple pan furnace enabled the users to operate the units for a longer duration than the units of lower pan number. Apparently, triple pan units are more economical due to long crushing duration as observed by Shivaramu et al. (2002).

Table 3. Distribution of jaggery producing respondents based on the quantity of cane crushed

Average cane crushed (t/d)	Single Pan		Double Pan		Triple Pan		Total	
	No.	%	No.	%	No.	%	No.	%
1.0 to 3.0	1	8.33	0	-	0	-	1	2.77
3.1 to 5.0	3	25.00	0	-	0	-	3	8.33
5.1 to 7.0	5	41.67	3	25.00	0	-	8	22.22
7.1 to 9.0	3	25.00	9	75.00	1	8.33	13	36.11
>9.0	0	-	0	-	11	91.67	11	30.55

Table 4. Distribution of jaggery producers based on duration of operation of jaggery unit

Duration (days/year)	Single Pan		Double Pan		Triple Pan		Total	
	No.	%	No.	%	No.	%	No.	%
121 – 150	1	8.33	-	-	-	-	1	3.00
151 – 180	1	8.33	-	-	-	-	1	3.00
181 – 210	6	50.00	1	8.33	1	8.33	8	22.00
211 – 240	4	33.33	4	33.33	2	16.67	10	28.00
240 – 270	-	-	2	16.67	4	33.33	6	17.00
271 – 300	-	-	5	41.67	3	25.00	8	22.00
> 301	-	-	-		2	16.67	2	6.00

Fuel used in jaggery units

Farmers used the locally available materials as a source of fuel for the jaggery units. Among the respondents, 69.4% used sugarcane bagasse, trash, dried coconut fronds and agricultural waste like paddy straw, maize straw, etc. The remaining 19.4% respondents, all triple pan adopters, used industrial wastes in addition to the above fuel combination. Further, the triple pan adopters informed that wastes, are the best substitute during rainy season which also increases the efficiency of heat utilization. KishanSingh (1985) observed similarly that it is possible to increase the efficiency of heat utilization by about 10% which would save 0.7 tonnes of bagasse per pan.

Fuel consumption in jaggery units

The fuel consumption in single pan furnace was 1.00 -1.50 quintals per boiling with 50.00% distribution in the two slots (Table 5). However, in double pan furnace, a higher proportion of respondents (66.67%) used 1.25-1.50 quintals per boiling and a lower proportion (25.00%) used 1.50-1.75 quintals per boiling. In triple pan furnace, 41.67% used 1.50-1.75 quintals per boiling whereas 25.00% used 1.75-2.00 quintals per boiling and 8.33% used two quintals and above per boiling. These figures indicated that triple pan adopters consumed more fuel per boiling (15 to 20% depending on the season) than single pan and double pan furnace adopters. Such higher consumption was due to continuous jaggery

Table 5. Distribution of jaggery producers based on fuel consumption per boiling

Fuel consumption (q/boiling)	Single Pan		Double Pan		Triple Pan		Total	
	No.	%	No.	%	No.	%	No.	%
1.00 - 1.25	6	50.00	1	8.33	2	16.67	9	25.00
1.25 - 1.50	6	50.00	8	66.67	1	8.33	15	41.66
1.50 - 1.75	-	-	3	25.00	5	41.67	8	22.22
1.75 - 2.00	-	-	-	-	3	25.00	3	8.33
> 2	-	-	-	-	1	8.33	1	2.77

preparation during day and night and throughout the period. However, based on the per pan average fuel consumption, triple pan furnace was found to be more efficient than double and single pan furnaces. Similar results were reported by Shivaramu et al (2002) and Chokkalingam (1985). Anwar (2010) has suggested providing parallel fins at the bottom of boiling pans to enhance the heat transfer. Charging of bagasse too has an impact on the thermal efficiency of jaggery making plants (Balaiah, 1989; Gehlawat, 1994). The consumption of bagasse in conventional three pan jaggery making plant is 2.26 kg per kilo of jaggery produced.

Economics of investment and production in jaggery units

Initial investment

The study indicated that the amount invested as initial cost by the respondents who have adopted different types of furnaces was based on their utility. The average initial investment by triple pan furnace adopters was high compared to single and double pan adopters (Table 6). With regard to investment on crusher unit, boiling pan, moulding unit and construction of furnace, the initial investment by triple pan adopters is almost five fold. This is due to design complexity and large size of these inputs compared to local types as was also observed by Chokkalingam (1985). Whatever be the number of pans, the major investments were on the construction of building, furnace, crusher unit and diesel engine.

Juice requirement for boiling

Nearly three fourth (72%) of the respondents used 700 to 900 litres of juice for each boiling. On an average, single pan furnace adopters used 829 liters, which is slightly higher than triple pan furnace adopters (813 litres) and double pan furnace adopters (754 litres) which corresponds to the pan size. Small pans probably confer advantages in terms of ease of handling and radiation of heat in the three tier set

Table 6. Distribution of respondents based on initial investment in jaggery units

Investment component	Single Pan			Double Pan			Triple Pan		
	No. of units	Unit cost (Lakh Rupees)	Total cost (Lakh Rupees)	No. of units	Unit cost (Lakh Rupees)	Total cost (Lakh Rupees)	No. of units (Lakh Rupees)	Unit cost (Lakh Rupees)	Total cost (Lakh Rupees)
Bullock pairs	9	0.33	2.97	11	0.40	4.44	11	0.41	4.51
10 hp electrical motor	6	0.22	1.32	11	0.62	6.82	12	0.35	4.20
10 hp diesel engine	12	0.24	2.88	10	0.24	2.35	11	0.23	2.54
Crusher unit	12	0.48	5.76	12	0.45	5.40	12	0.84	10.08
Boiling pans	12	0.12	1.44	11	0.25	2.75	38	0.11	4.18
Construction of building	12	1.28	15.36	12	1.54	18.48	12	1.50	18.00
Construction of furnace	12	0.06	0.72	12	0.10	1.20	9	3.36	30.24
Electrical accessories	10	0.16	1.60	12	0.27	3.24	12	0.27	3.24

up. Similar results were reported by Usha Ravindra et al. (2004).

Number of boiling cycles per day

It was seen that 31% of the respondents managed 6 - 7 boiling cycles/day, 22% of respondents achieved 9- 10 boiling cycles and 25% completed >10 boiling cycles /day. Higher number of boilings could be achieved due to efficient utilization of heat, use of higher quantity of fuel material and continuous boiling arrangements of triple pan furnace system.

Boiling period in minutes

Half of the respondents reported that 60-120 minutes is required for each boiling and 39% reported it to be 120-150 minutes / boiling. However, the time required for boiling varied with the type of furnace used. The average time consumption of triple pan adopters was 80 to 110 minutes, which was almost half the time consumed by single pan furnace adopters (132-150 minutes).This is mainly due to continuous warming of all pans or maintaining the boiling condition continuously. Further, due to non stop jaggery preparation, the labour force was efficiently used in triple pan furnace. Similar results were reported by Shivaramu et al. (2002) and Usha Ravindra et al. (2004).

Type of jaggery

The type of jaggery made depends on the purpose, either for local market or for export. The study revealed that 36% of the respondents made small balls (locally called *goli*), 33% made slab jaggery using wooden moulds, 25% made bucket type and only 6% made jaggery cubes. Majority of triple pan adopters made bucket type jaggery followed by mould type as it requires less labour than for small balls (*goli*). Single pan adopters made more small balls (*goli*) as it is easy to market locally whereas moulds and bucket type jaggery are largely for export purpose to other countries and abroad.

Labour requirement and cost

In general, it was found that the labour cost of triple pan adopters was marginally higher than single furnace adopters due to maintenance of three pans. Such labor requirement, as was also observed earlier (Bisht and Anwar 1985; Shivaramu et al. 2002) could be due to employment of skilled labour, especially handling the three pans simultaneously and handling the huge quantum of crushing, besides for boiling, jaggery making and packing and manufacturing.

Quantity of jaggery obtained

Among the respondents, 58% obtained 0.7 to 0.9 q jaggery/pan/boiling and 28% produced 1.0 to 1.20 q jaggery/pan/boiling. Average jaggery output / pan / boiling was higher in single pan (1.19 q) than triple pan (0.87 q) which corresponds to the pan size and juice volume.

Conclusion

The study revealed that three pan furnace units were found to be more fuel efficient, economic and profitable under higher volume operation. The fuel thus saved can be made use of for other uses like paper making etc. profitably, which will add to the income of the jaggery farmers. To improve the performance and profitability of jaggery making plants, more technical interventions are required to increase the combustion and thermal efficiencies, making the process environment friendly. The observations made during the study revealed that the technical knowhow involved in the manufacture of jaggery is very crude which can be improved through application of modern technology taking into consideration the ecological factors. Considering the

health benefits of jaggery, proper care should be taken to improve the jaggery industry and sugarcane cultivation for jaggery making, which is presently handled by the unorganized sector.

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