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Red gram milling unit as a rural entrepreneurship in tribal areas: Economics and food sustainability

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Abstract
Pulses milling is second largest agro food processing industry in Adilabad district of India after cotton ginning industries. Dehusking and splitting of Red gram into dhal is an essential process as Red gram dhal is an important food ingredient in the regular vegetarian meals of Indians. The most influential factors in dhal milling enterprise are production and productivity of red gram, minimum support prices (MSP) for raw red gram, dhal yield during processing and the market prices for dhal. The commercial dhal mill operators and dhal milling units run by farmer's producer's organisations are participating in the open tender system and sourcing the raw red gram at 42-45% lesser price ranging from Rs. 3000 to 3500 when compared to minimum support price of raw red gram. Then the cost of production of red gram dhal in commercial dhal milling units is reduced from Rs.2300 to 2500 and benefit cost (B:C) ratio is 1.12:1. Value-addition to red gram and other pulses at small and medium scale will not only enable cheaper dhal based food products available to rural population, but also address the protein energy malnutrition problems among rural population and strengthen the rural economy.

Keywords: red gram, dhal milling, dhal recovery, market price, sustainable income

Introduction
Adilabad is one of the districts inhabited by highest number of tribal people in India with more than 75% rural population and among them 35% of people are tribes. Majority of the farmers are marginal and small accounting to 67.8% of total land holdings in the district. In total gross cropped area of the district, pulses, soybean and cotton occupy 18%, 12% and 77% area respectively (Directorate of Economic and Statistics, 2016-17) [4]. Red gram [*Cajanas cajan* (L.) Millsp.] is an important major pulse crop cultivated by tribal farmers in the district after Cotton and Soybean. The area under Red gram is 19447 ha, contributing to about 11% of the district area under pulses. The yield of red gram is around 1025 kg.ha^{-1}. In terms of production, Adilabad contributes to about 38229 MT with 36% share of total Telangana state Red gram production (Directorate of Economic and Statistics, 2016-17) [4]. Red gram dhal (Tur dhal) is an important dietary constituent and source of dietary protein for large segments of the world's population, particularly in those countries where the consumption of animal protein is limited by non availability or is self-imposed because of religious or cultural habits especially for the vegetarian population of India (Joyce Boye *et al*., 2010) [8]. Red gram is mostly consumed as dry split dhal and or used in the production of flour. Split and whole pulses are usually cooked and served as part of a meal with rice or traditional Indian bread (roti). In some kind of traditional Indian snacks and Namkeens, Red gram flour is an important ingredient. As snack food is also a fast growing market in India, due to rising incomes and increased number of consumers in II tier cities, pulse flours will be in higher demand (Anon. 2015) [1]. Red gram is an excellent source of protein (20-22%), supplementing energy rich cereal diets in a mainly vegetarian population. Red gram is a multipurpose crop that fits very well in the context of sustainable agriculture. In addition to food, it can be used as fodder, feed, fuel, functional utility (for making baskets, huts, fences, etc.), fertilizer (fixes atmospheric nitrogen and releases phosphorus), forest use (re-forestation, lac production), and even for pharmaceutical purposes (Gowda *et al*., 2015) [5]. The consumption of 100 g of Red gram dhal provides 21.7 g protein, 1.5 g fat, 55.23 g carbohydrate, 9.06g dietary fibre, 321.7 kcal energy, 108µg total

folates, 2.63 mg Zinc and 71.7 mg calcium (Longvah *et al*., 2017) [9]. The protein requirements continue to be a global issue with heightened concerns about food security and protein malnutrition in rural areas of India. Protein Calorie Malnutrition (PCM)' is a major concern in Adilabad district especially in infants, young children and nursing mothers. About 35.8% children below 5 years are under weight (weight for age), 38.3% are stunted (Height for age) and 67.8% are suffering with anaemia (NFHS-4 data, 2015-16) [11]. National Nutrition Monitoring Bureau (NNMB, 2006) [3], India surveys indicate that the average consumption of pulses and legumes like Red gram, Green gram, Bengal gram and black gram, which are important source of protein was less than 50% of RDA. The current pulses per capita consumption in Adilabad district is 44g/day while that of Recommended Dietary Allowances (RDA) is 80g/day (NNMB, 2006). The total consumption of Red gram in Telangana state per year is around 300877.53 metric tonnes and per capita consumption is 24g/day (Sanjiv Kumar *et al*., 2017) [14].

Establishing large scale dhal milling units with the state of art facilities and small and medium scale units at rural catchment areas are inevitable in contributing to achieve the laudable objective of Government of India to "Double Famer's Incomes by 2022". India is gaining greater momentum in production and productivity of pulses and the demand for quality dhal and convenience driven dhal based meals and snacks are further slated to increase at an even more significant pace in the future. Thus the post harvest management through dhal milling is an important practice to reduce post harvest losses and add value to the produce to stabilize the price fluctuations of whole Red gram as well as dhal during peak seasons, which either causes distress sales at farmer level or higher retail price inflation in the Indian market.

In view of the above advantages and sustainable development of Red gram growers and food secure future of the tribal families, the study was undertaken to assess economics and sustainability of Dhal milling Units for Rural Entrepreneurship in tribal Areas of Adilabad District. The most influential parameters, which affect the economics of dhal milling enterprise, are (i) Production and productivity of Red gram, (ii) Minimum Support prices (MSP), (iii) Market prices for dhal and (iv) Dhal recovery percentage

Materials and Methods

A study was conducted in Adilabad district by identifying different dhal mills with varying capacity located in different parts of district. The data was collected by conducting trials on different mills with various pre-treatments before and after milling of Red gram into dhal.

1. Red gram

A high yielding improved variety of Red gram PRG-176 developed by Professor Jayashankar Telangana State Agricultural University, Hyderabad was selected for the study. The PRG 176 variety was popularized by Krishi Vigyan Kendra, Adilabad in the district through National Food Security Mission for better yields and improved cooking quality and taste of dhal. Raw red gram was procured from the Krishi Vigyan Kendra, Adilabad. The samples were cleaned, graded and stored in gunny bags until further processing.

2. Dhal milling units

Twelve (12 nos) small and medium scale dhal milling unit's located in tribal areas across the district were identified which were of capacity ranging from 0.5 tonnes per day to 5 tonnes per day. All the units were assessed for the economics and sustainability of rural entrepreneurship through dhal milling.

3. Pre-milling treatments

Three different pre-milling treatments were chosen for studying the dhal recovery of Red gram based on the practices followed by the entrepreneurs in the district. Slight modifications were made in the treatment time based on studies conducted by Sharanagouda *et al*., (2014) [16] and preliminary experimental trials were also conducted to achieve maximum dhal recovery and best cooking quality dhal. The details of treatments and unit operations are presented in Table 1 and Figure 1.

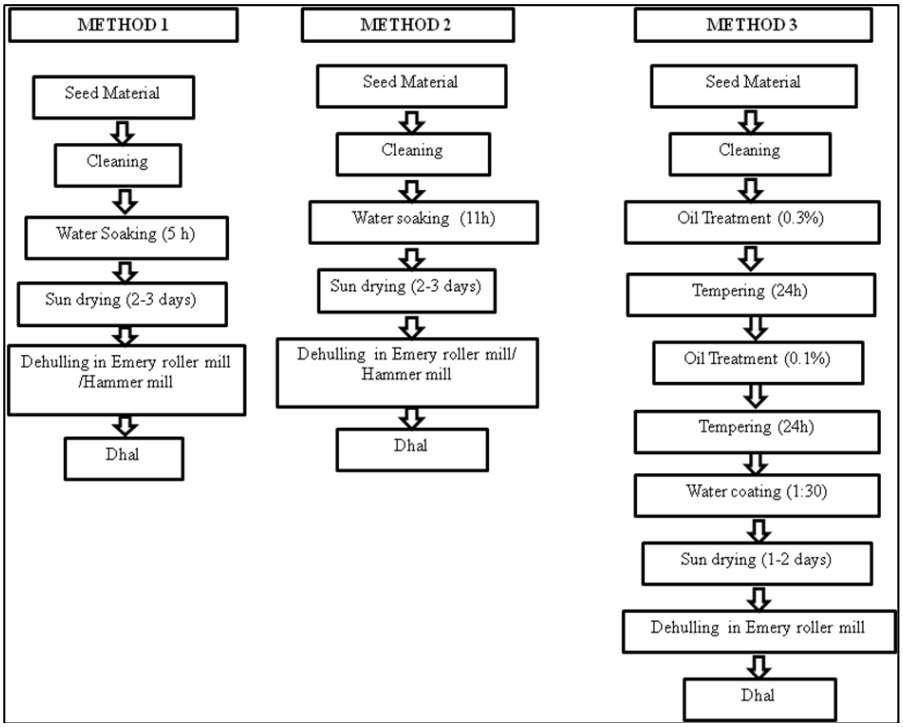

Fig 1: Dhal Milling Process flow chart

4. Dhal Milling

Traditional method of milling is most commonly followed by dhal mill entrepreneurs in the district. However; large scale milling involves processing of large quantities of pulses in plants of bigger capacities. Dhal milling involves three important operations required in the milling of pulses i) Pre-milling treatment – to loosen the seed coat, (ii) Dehusking or husk removal – to add culinary properties and (iii) Splitting – to convert dehusked whole (gota) into dal (Prasoon Verma, 2018) [12]. The machinery used in Adilabad district works on the principle of abrasion and impact forces. Even though, the basic milling procedure is similar, specifics of dehusking methods vary widely from one dhal mill to another dhal mill and region to region. Depending upon pulse type, variety, milling process and machineries used, there is 5-10% variation in milling recoveries (Mangaraj *et al*., 2005) [10]. About 80% of total pulse production in India is either consumed in form of dal or powder. Milling fractions (husk, unhulled, brokens, powder, whole dehulled, dal and split, partially hulled) were separated from milled output by hand picking and using set of sieves (BSS 6, BSS 8, BSS 16, BSS 18, BSS 25) and stored in sample covers. Then the separated fractions were weighed and hulling efficiency, finished dhal recovery, unhulled and brokens percent were calculated using the following formulae reported by Saxena (1985) [15]. All the experimental trails were conducted on Dhal mill (Make, Khamadhanu, Nagpoor, India) with the capacity of 1 Tonne per day located at Sunkidi Village, Adilabad district, India.

Dehulling efficiency (%) = $(1\text{-}Un/T)\ x\ (F_p/F_p+B_r+P_o)\ x100$

Where, U_n, Unhulled grain mass (g); T, Sample mass (g); F_p, Finished product, consisting of splits and whole dehusked grain (g); B_r, Brokens mass (g); P_o, Powder mass (g).
Finished product recovery (%) = F_p/T x 100
Where, F_p, Finished product, consisting of splits and whole dehusked grain (g); *T*, Sample weight (g).

Unhulled (per cent) = U_n/T x 100
Broken (per cent) = B_r/T x 100

5. Economics

The economics and sustainability of rural entrepreneurs in dhal milling processing has been conducted using the data of Minimum Support Price offered local agriculture markets and processing cost and whole sale price of dhal at dhal milling unit. The data collected were presented in tabular form to facilitate easy comparisons. The investment, pattern cost of procurement and returns in Red gram milling and problems faced by the processors and farmers were studied using SWOT analysis. The data were summarized with the help of statistical tools like averages and percentages to obtain meaningful inferences.

Results and Discussions

Dehulling efficiency and Dhal recovery

The dehulling efficiency in pre-treated red gram varied from 96.4 to 98.6%, which were significantly higher than the untreated or control sample (49.4%) in medium sized dhal mill with the capacity of 1 Tonne per day. Lower dehulling efficiency of Red gram may be attributed to lower moisture content and also due to brittleness of grain resulting into breakage of grains during milling. The results were in accordance with (Wani *et al*.,) [13] who reported dehulling efficiency was low for the untreated green gram. Dhal milling of mustard oil pre-treated red gram with subsequent tempering, water spraying and drying resulted into dhal recovery in the range of 76.13-77.34% as against 73.56 to 75.81% for water soaking and subsequent drying of red gram (Table 1). Sharanagouda *et al*., (2014) [16] observed that Gulyal variety treated with mustard oil recorded maximum hulling efficiency (79.4%) and finished product (68.8%) when compared to a Maruti and Asha variety. The commercial dhal milling units generally follow the application of oil as pretreatment and subsequent tempering before dehulling of pigeon pea. This is due to penetration of the oil through the husk of cotyledons that helps in release of its mucilaginous bonds. The loosening process may be slow, but the husk can be totally loosened (J P Sinha *et al*., 2017; Deshpande *et al*., 2007) [7, 2]. Other milling fractions obtained for oil treated red gram were Dehusked whole grains. Unhusked fractions were 3.7%, as compared to 38.56% in control. The percentage of husk obtained was in the range of 16.89% to 20.53%. The percentage of husk and powder was more in case of the red gram soaked in water for 5h and subsequent drying for 2-3 days.

Table 1: Effect of pretreatments on dhal yields in dhal milling process in mini dhal mill

S. No	Pre-treatments	Dehullingg efficiency (%)	Dhal Recovery (%)	Dehusked whole grains/ unhusked (%)	Husk and Powder (%)
1	Control	49.46±0.56	42.82±0.61	38.56±0.36	16.89±0.61
2	Water Soaking + Sun drying	96.41±0.31	73.56±0.29	5.22±0.86	20.53±0.16
3	Water Soaking (11h) + Sun drying	97.79±0.26	75.81±0.18	4.2±0.73	20.1±0.56
4	Mustard oil treatment + Tempering+ Water spraying + Sun drying	98.61±0.14	76.13±0.27	3.7±0.79	19.74±0.46

All the values are triplicate of analysis and presented as means ± standard error

The milling responses of Red gram as influenced by soaking period and the finished product recovery were high (75.81%) in case of red gram soaked for the period of 11 h when compared to soaking for a period of 5h. The differences in milling fractions obtained with the pre-treatment were possibly the result of varying extent of loosening of husk from the cotyledons and reducing the influence of mucilaginous bonds. Cooking time and taste of dhal is also an important factor for selection of pre-treatment before milling of red gram into dhal. Entrepreneurs received the feedback from the consumers through survey that cooking quality and storage life of dhal was less when red gram is soaked and processed than compared to oil treated pre-treatment process. Similar trend of decrease in cooking time after oil treatment was reported by Deshpande *et al*., (2007) [2] that cooking time as 37 min for linseed oil treated pigeon pea as compared to 43 min for raw untreated grain.

Economics

Comparative analysis of value addition to Red gram through Dhal milling (Figure 2) revealed that the minimum support prices of Red gram have increased from Rs. 4300 to 5450 during the period from 2013-14 to 2018-19. A shortage of red gram production during the years 2014-15 and 2015-16 has lead to increase in the whole sale prices of dhal at factory up to Rs.12000/100kg. The retail prices of the dhal increased up to Rs.200/kg in some of the metropolitan cities in India. The average prices of dhal decreased from the year 2016-17 to 2018-19 and 50% dhal prices decreased due to increased production of Red gram (IASL, 2018) [6].

When cost of dhal production was compared with the returns on processing of 100kg of Red gram into dhal, it was 25% lesser (Table 2 and 3). This is mainly attributed to the cost of raw materials and, increase in 25% minimum support price of Red gram from 2013-14 to 2018-19. The operation of dhal mill at lesser than the breakeven point is not economical and sustainable. In order to reduce interest on investment and making of dhal milling unit into a sustainable business entity, small and medium sized entrepreneurs in the district are converting the Red gram into dhal on job work basis apart from commercial production. Local whole sale traders and the farmers nearby villages convert their raw red gram into dhal through small and medium sized dhal mills (Table 4) for domestic consumption and other commercial purposes by paying Rs. 5/kg.

Table 2: Economics of Dhal Milling for processing of 100 kg of Red gram into dhal in Mini Dhal Mill

S. No	Particulars	Amount (Rs.)	
		MSP rate	Open tender price
1	Cost of Raw Red gram (100 kg) during 2017-18	5450	3160
2	Processing charges @Rs.3/kg	300	300
3	Labour charges (2 members @ Rs. 300 per person for 2 days)	1200	1200
Total cost of Production in Rs.		6950	4660

Source: Authors' estimates based on reports compiled from dhal milling entrepreneurs, red gram growers and apex bodies of the ministries of agriculture, government of Telangana and India.

Table 3: Milling fractions obtained from 100 kg of raw red gram in commercial dhal mill

S. No	Particulars	Quantity in kg	Market price Rs./kg	Total amount (Rs.)
1	Premium quality Dhal recovery is **(**57.5%)	57.5	65	3738
2	Second grade (B Grade) dhal recovery 18.6%)	18.6	52	967
3	Dehusked whole or Un husked grains 4%	4.0	65	260
4	Husk and powder (20%)	20.0	15	300
Total returns on processing of 100kg of Red gram into dhal in Rs.				5265

Source: Authors' estimates based on reports compiled from dhal milling entrepreneurs, red gram growers and apex bodies of the ministries of agriculture and Civil supply department of government of Telangana and India.

Large size commercial dhal mill in the district run by Farmers Producing Organization (FPO) is recording high profits due to consensus of federation, the member farmers are invariably process their produce into dhal and further federation creates forward linkages with the market. FPO's in the district are also participating in open tender system for procuring of Red gram from government agencies like Telangana State Co-operative Marketing Federation Ltd (TS Markfed) and National Agricultural Cooperative Marketing Federation of India Ltd.(NAFED) with less than 42-45% subsidy prices on minimum support price.

Table 4: Income generation by entrepreneurs by job work basis in a Year

S.No	Particulars of Milling unit	Capacity (in Tonnes/day)	Quantity processed (kg)	Conversion charges (Rs.)
1	Medium sized dhal Mill (Make, Khamadhanu, Nagpoor)	1	80000	400000
2	Mini Dhal mill (Make,Maa Durga Plastic Products, Nagpoor)	0.5	40000	200000
3	Multipurpose Mill (local make)	0.4	30000	150000

Source: Authors' estimates based on reports compiled from dhal milling entrepreneurs, red gram growers in the district.

The government agencies are procuring raw red gram from the farmers with minimum support price (MSP) fixed by government of India as shown in figure 2. The government agencies in the district are selling the red gram after keeping buffer stock to the traders and processors through open tender system, before beginning of next season to procure new stock from the farmers.

The commercial dhal mill operators and other FPO run dhal milling unit managements participate in the open tender system and source the raw red gram at 42-45% lesser price ranging from Rs. 3000 to 3500 when compared to minimum support price of raw red gram as shown in the Table 4. Then the cost of production of red gram dhal in commercial dhal milling units is reduced from Rs.2300 to 2500 and benefit cost (B:C) ratio is 1.12:1. When dhal prices increase in the market to Rs. 100 or 120 per kg, then expected benefit cost (B:C) ratio would be 2.14: 1 and 2.57: 1 respectively. Few small scale entrepreneur also process 20 tonnes of Red gram produced in their farm lands and sold in the market at Rs.60 per kg and recorded benefit cost (B:C) ratio 5:1. The detailed economic sustainability of dhal milling units at rural areas is explained through SWOT analysis in Table 5.

Table 5: SWOT Analysis of Rural Entrepreneurship in dhal milling

Strength	• Fertile soils in the district • Rapid urbanization is driving consumerism in Tier-II & Tier-III cities • Growing penetration of small and medium scale dhal milling units in rural areas • Tailor made and region specific dhal based meals and snacks • Women farmers and Rural youth
Weakness	• Rain fed situations • Non adoption of improved management practices • Non availability of milling units at catchment areas • Price fluctuations in the market during peak seasons • Lower MSP or low prices for dhal in the market
Opportunity	• Developing resistant varieties to biotic (wilt, SMD, Phytophthora, and pod borer) and abiotic (moisture, high or cold temperature) stresses. • Development of super-short duration genotypes • Untapped rural markets and seed to plate value chain development • Rising pulses demand in future • Rising per capita income coupled with increasing awareness among consumers • Organic dhal • Doubling of farm income • Better control of retail price inflation for dhal
Threats	• Climate change and unfavourable rainfall (delayed, erratic, improper • distribution) • Lower productivity • Low dhal recovery in small and medium scale units • Competition from multinational companies and retail houses

Source: Compiled from reports of the apex bodies of the ministries of agriculture of government of India, ICAR, India and ICRISAT, India.

Conclusion

Dhal milling is second largest agro food processing industry in the district after cotton ginning industries. Dehusking and splitting of Red gram into dhal is an essential process as Red gram dhal is an important food ingredient in the regular vegetarian meals. In this study it was concluded that Red gram pre treated with mustard oil (0.4%) subsequent tempering and water spraying has yielded better hulling efficiency of 98.61% and finished product recovery of 76.13%, which was superior over other treatments. The cooking quality and storage life of dhal was poor when red gram is soaked and processed than compared to oil treated pre-treatment process. The commercial dhal mill operators and other FPO run dhal milling unit managements are participating in the open tender system called by government agencies and sourcing the raw red gram at 42-45% lesser price ranging from Rs. 3000 to 3500 when compared to minimum support price of raw red gram ranging from Rs. 5000 to 5600. Then the cost of production of red gram dhal in commercial dhal milling units is reduced from Rs.2300 to 2500 and benefit cost (B:C) ratio was 1.12:1. When dhal prices raises in the market at Rs. 100 or 120 per kg then expected benefit cost (B: C) ratio would be 2.14: 1 and 2.57: 1 respectively. Few small scale entrepreneurs in the district also process an average 20-80 tonnes of Red gram per year on job work basis by charging Rs. 5000 per 1 tonne of red gram. One entrepreneur processed 20 tonnes of Red gram produced in his 40 acres of farm land and sold in the market at Rs.60 per kg and recorded benefit cost (B:C) ratio 5:1. Establishment of mini Dhal milling units at rural areas have the potential to enhance farmer's income, employment opportunities and better stabilization of price inflation in the Indian market during drought situations. Value-addition to red gram and other pulses at cottage scale will not only make cheaper food products available to rural population but also address the protein energy malnutrition problems among rural population and strengthen the rural economy.

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