Creation of Demand for Millet Foods through PCS Value Chain

FINAL REPORT

National Agricultural Innovation Project

(Indian Council of Agricultural Research)

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Directorate of Sorghum Research

Rajendranagar, Hyderabad- 500 030, A.P

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Executive Summary

The direct consumption of sorghum and millets as food has significantly declined over the past three decades. The decrease in demand led to the decline in sorghum production from 9.86 million tonnes in TE 1969-70 to 7.29 million tonnes during TE 2009-10 (Dayakar et al., 2011). The major reasons for the decrease in sorghum consumption are that it is inconvenient, cumbersome and time-consuming to prepare food from it, lack of processing technologies, lack of awareness of nutritional merits and also the government policy of disincentiveness towards millets and favoring of supply of fine cereals at subsidized prices. It has become imperative to reorient the efforts on the sorghum crop to generate demand through value-addition of processed foods through diversification of processing technologies, nutritional evaluation and creation of awareness backed by backward integration. To augment such efforts, "Production to Consumption System" (PCS) model for specific products and markets are needed. The sub-project of NAIP-Millets Value Chain focuses on such an effort on selected millet foods with special case of sorghum; so that once the pilot project is successful the model is replicated to other millets.

In order to revive the demand of millets in India, Directorate of Sorghum Research (DSR) led consortium under the NAIP liberal funding, has undertaken interventions to bridge the identified gaps on different aspects of on-farm production, processing diversification, nutritional certification, promotion and marketing of sorghum in the Indian market. The attempt enabled to bring all the stakeholders in production to consumption system value chain on a common platform and link poor dry land farmers with market as well as consumer. In this regard, the DSR as the lead institute has built linkages with partners NIN, SAU's and ITC, a private institute. Similarly with DFRL, CFTRI, CIAE and CIPHET.

The backward integration model of product specific on-farm production covering 3000 acres in Parbhani (rabi) and Nanded (kharif) of Maharashtra and in Adilabad (kharif for 2 seasons) in AP was tested for 4 successful years under e-choupal market assured model of ITC (ABD). The beneficiaries are technology backstopped by DSR product specific cultivars (more than 12) bringing change in the mindset of farmers on intensive commercial aspects of sorghum cultivation. The recommended package of practices (PoP) for receiving better yield and quality was extended in PPP mode of farm extension services.The impact is visible through increased farm productivity and assured net incomes over the bench marks determined during the base line survey conducted earlier, which in turn led to shift in allocation of sorghum cultivation from marginal to better soil and water rich environments which is an indicator of stabilization of acreage in the study area.

In fact, backward integration resulted to overall improvement in the crop scenario such as the quality of the produce (sorghum grain), better utilization of fallow land, and commercial colour to the crop through sustainable linkage among all the stakeholders in the value chain.

Value Addition through Processing Interventions in Millets (DSR & ANGRAU)

One of the major reasons for declined consumption of Sorghum is due to inconvenience in its product preparation. In this regard, interventions through diversification of processing technologies related to sorghum are attempted to remove the inconveniences and develop, fine tune and standardize sorghum product technologies. For this purpose, the DSR has installed and retrofitted 30 machineries under NAIP. Primary processing and secondary processing methods have been developed and fine-tuned using those equipments and has come out with good quality of 30 sorghum product technologies such as multi grain atta, semolina, flakes, extruded products (vermicelli and pasta), biscuits etc., similarly ANGRAU has come up with another 10 pearl millet and sorghum product technologies. Of which, 9 DSR products and 5 ANGRAU products are targeted for commercialization.

Interventions are made to improve the nutritional quality as well as the consumer acceptability of Sorghum. Processing interventions is continuing at DSR to target at niche segment as well as mass marketing at the national level.

Nutritional Evaluation and Certification (by NIN): The organoleptic study of 15 sorghum products developed by the DSR conducted by the NIN show that sorghum products are superior with rice products and on par with wheat based products. This study was followed by nutritional benefits of sorghum products in diabetes and school children. The studies established Sorghum offer better nutrition in general over the market available products made from wheat, rice and maize. The amino acid profile of pulse (Soy blend) incorporated Jowar products were containing better amount of lysine, which is limiting factor in Jowar and also overcome the deficiency of micro nutrients. Glycemic Index of Jowar foods was analyzed to determine the mean glycemic response for reference and test foods using International standards. The study reported that there was a decrease in the mean incremental area under glucose curve (IAUC) levels after consuming Jowar products.

Entrepreneurship Development: Entrepreneurship Development (ED) programme on sorghum cultivation, processing, and marketing of Jowar based products was jointly organized by ITC and DSR with active participation from institutes like DSR, ITC, ANGRAU, NIN and College of Home Science, MAU. Machineries of standardized Sorghum products were demonstrated to the farmers. 2000 Rural women and another 3000 SHG's, farmers, urban entrepreneurs are trained on development in Sorghum food processing.

Promotion and Popularization: DSR launched its own brand as "Eatrite" and the products are popularized as healthy foods while ANGRAU has branded their products as ANGRAU foods. The sorghum products are fine-tuned and standardized now labeled and branded as health foods based on nutritive value established by NIN studies and targeting separately for urban up marketing (middle and higher income classes) and rural markets. Found a place in shelf space of retail markets in Hyderabad. Thanks for the promotion which was aggressively undertaken by DSR led consortium on awareness of nutritional merits of sorghum covering 360 degree

communication strategies. For promotion of Eatrite products nutritionists/ doctors/ dieticians were sensitized by DSR and for commercial portal DSR launched www.ieatrite.com website.

Simultaneously outsourced the event managers for popularization of sorghum products (360 degree communication, brand designing logo, *etc* with BTL and ATL strategies implemented) in urban markets & New age Media. Massive awareness is created on sorghum as health and nutria food through Road shows (100+) in public parks, malls, and institutes *etc* in Hyderabad and in exhibitions in imparting awareness of sorghum to across 40000 consumers through fabricated *Jowar Rath* in Pune, Bangalore, Jabalpur, Chennai, Coimbatore, New Delhi etc. Rural consumer drive was undertaken by ITC rural choupal haats to sensitize the convenience and nutritional aspects of the outputs from the sub-project.

Commercialization: The pilot commercialization of sorghum products at Hyderabad starts with launching of DSR brand "Eatrite" with a tag line 'Eat Jowar –stay healthy'. The range of products under this brand includes: Sorghum Rich Multigrain Flour, Sorghum Semolina, Sorghum Pasta, Sorghum Vermicelli, Sorghum Flakes& Sorghum Roasted Flakes, and Sorghum Biscuits/Cookies. In this regard, 5 formats of business plans are commercialized for Jowar products evolved under their relative merit assessed in terms of farmer's share in the consumer rupee. Suitable packaging, labeling, marketing and pricing strategies are adopted for targeting them to urban markets (DSR & ANGRAU). Thus interventions made possible to provide convenient options for consumers among sorghum foods.

This project developed a model for PCS for millets' foods. This led to enhanced consumption levels of targeted groups, income and employment of stakeholders through value-addition and branding of sorghum and millets as health foods. The demonstration of market-linked production, procurement, primary processing and buy-back (procurement) arrangements were done through ITC's Ltd market assurance model and this was important to establish the confidence of entrepreneurs for Supply chain management. DSR (ICAR) also benefitted by this model, as we will have a new and effective means of disseminating our new cultivars and production technology as done already by a few seed companies.

The above discussed issues are addressed by an inter-disciplinary team of experts from various disciplines such as food and nutrition, food technology, clinical studies, biochemistry, mechanical engineering, economics, social sciences, entomology, economic botany and genetic conservation. Consortium lead centre is adequately equipped with required expertise and experience in these areas. The partners and associates in respective operational realm are rightly chosen and sought safeguard and assurances. Complimentary efforts, through other ICAR programs are also an important part of this project, to ensure minimum critical mass of efforts, and eventual follow-up even beyond the life of this project.

Under the National Agricultural Innovation Project the Directorate of Sorghum Research and the consortium partners explored various issues ranging from farm level to the consumers as value added convenient food products, undertaken in Public Private Partnership mode. The synergic efforts resulted in increase of yield and income of sorghum farmers and simultaneously their

marketable surplus; various nutritionally rich sorghum product technologies were developed and successfully commercialized on pilot scale at Hyderabad. Apart from licensing private enterprises for production and marketing these technologies, collaborative works are also taken up for product development. Implementation of effective promotional strategies and policy sensitization attracted entrepreneurs and policy makers to consider sorghum as priority.

Socio-Economic Impact (Economic Rate of Return): Intensive sorghum cultivation through technological backstopping with end-product specific improved cultivars in public private resulted to increase in net income of the participating farmers by 395% in kharif and 69.15% in rabi (average of 4 years) over baseline. The output-input ratio worked out to be 3.02 in rabi and 2.67 in Kharif. In fact, backward integration resulted to overall improvement in the crop scenario such as the quality of the produce (sorghum grain), better utilization of fallow land, and commercial color to the crop through sustainable linkage among all the stakeholders in the value chain.

The overall interventions under the sub-project viz., on-farm production, processing intervention, nutritional certification, promotion & marketing, and entrepreneurship development has brought all the stakeholders on a common platform in production to consumption system of value chain and link poor dryland farmers with market as well as consumer. The products that we developed and standardised (more than 30), out of which the shortlisted products that have been commercialized viz., Jowar rawa, Jowar pasta, Jowar vermicelli, Jowar flakes, Jowar biscuits, Jowar pops and Jowar based multigrain atta; has proven the feasibility of processing and commercialization of sorghum and millets in both rural and urban areas, irrespective of traditional and non-traditional areas.

Considering these NAIP-MVC successful experiences & the future prospects in the area of healthy sorghum processed foods, Government of India allocated Rs.300 crores in 2011 under Rashtriya Krishi Vikas Yojana for promotion of millets as Nutri-Cereals under INSIMP project-replication of NAIP- Millets Value Chain. As such, more than 200 processing clusters have been set up across the country. Now, with the setting up of Centre of Excellence (CoE), DSR has been actively working on penetrating the consumer eating habits by producing, promoting and popularizing various Jowar based products. Promotional activities have been aggressively conducted in outsourcing mode through Road Shows in public parks and malls, exhibitions, health awareness programmes, social network campaign, media coverage, video films and booklets, internet, seminars etc. Besides, DSR also encourages entrepreneurship development to involve all the potential stakeholders in the value addition and commercialization of millets.

It is worth noting that 15 MoUs and 3 MoA have been signed with the entrepreneurs including MoU with M/s Britannnia industries Limited has now joined hands with DSR for production and marketing sorghum food products while many more are in queue to sign MoU with DSR for the same purpose. This shows that there is a growing tendency among the food players to invest more in sorghum and millets foods business and consumption of millets will once again revive in the country.

Environmental Impact

- **On farm production for specific end uses:** By mitigating grain mold on kharif sorghum prescribed harvesting at physiological maturity and drying, helped in accruing good market price of the output. Secondly pearling and other grain treatments too enhanced the grain and the price per kg is fetched on par with normal grain.
- Sorghum cultivation has had positive effect on use and availability of water resources being a dryland crop. The positive effects of change in cropping pattern on soil, water and environment are evident from higher productivity and the net returns from sorghum *vis-a-vis* other crops.
- Integrated farm extension services with buy-back provided by ITC (ABD). The best bet practices and crop management is in place with training on IPM & IPNS to participating farmers in PPP mode with backing of DSR.
- Transport and processing of produce: Clean grain for marketing could be implemented with grader/destoner/aspirator.
- Nutritional evaluation of the millet foods for diabetic and obese patients. Millets diet for diabetic and obese groups available
- Implementation of HACCP: NIN conducted compliance study across the value chain and certified the food products are meeting safety compliance which is in place for millet foods

Sustainability Plan

1. With the positive impact of on-farm sorghum cultivation being visible from the past 6 years, through revamped image of sorghum cultivation with commercial color more farmers in the targeted districts are also being linked up with INSIMP programme.
2. All the participating farmers were given entrepreneurship development training to involve themselves in on-farm value addition. Under INSIMP processing clusters are provided at free of cost to encourage farm level value addition, if they are willing to for obtaining higher net returns.
3. The sorghum products commercialization will continue under DSR brand *'Eatrite'* and *"ANGRAU foods"* either directly by DSR/ANGRAU or through those entered MoU's with DSR/ANGRAU (15+5 entrepreneurs).
4. INSIMP, a DAC programme which aims millet promotion in the country will now be merged with NFSM to further the objectives of the subproject if not in totality.
5. The awareness creation and entrepreneurship development will also be the DSR activity, however external funding is planned through platform research on secondary agriculture. However, its take off would be likely from 2015

6. However a gap funding for six months after March, 2014 for continuation of activities as working capital will be of immense value.

7. The big player's entry such as M/s Britannia is expected to generate demand for sorghum cultivation in long term through their product launches which is expected in another 6-9 months.

8. DSR has started building a wide network to market sorghum products by involving government agencies, entrepreneurs, wholesalers and retailers making Hyderabad as the pilot study area which will be sealed soon. However, horizontal expansion is envisaged to target market across the country even in non-traditional sorghum consuming urban metros such as Delhi, Bangalore, Chennai, and Pune in phase I and expand it to other areas in phase II.

Part-I: General Information of Sub-project

1. **Title of the sub-project:** Creation of Demand for Millet Foods through PCS Value-Chain
2. **Sub-project code:** 20002
3. **Component:** II (Two)
4. **Date of sanction of sub-project:** 20.12.2007
5. **Date of completion:** 30.06.2012
6. **Extension if granted, from** 01.07.2012 to 31.03.2014
7. **Duration of the sub project:** 6 years 3 months
8. **Total sanctioned amount for the sub-project: Rs** 881.27 lakhs
9. **Total expenditure of the sub-project:** Rs.775.85 lakhs (As on 20.03.2014)
10. **Consortium leader:** Dr. JV Patil, Director, Directorate of Sorghum Research, Rajendranagar, Hyderabad-500030, Andhra Pradesh, India.
    Tel. +91-040-24015349, +91-040-24018651, Fax. +91-040–24016378
    E-mail: dsrhyd-ap@nic.in; jvp@sorghum.res.in, www.sorghum.res.in
11. **List of Consortium partners:**

	Name of CPI/ CCPI with designation	**Name of organization and address, phone & fax, email**	**Duration (From-To)**	**Budget (Rs in Lakhs)**
CPI	Dr. B Dayakar Rao, Principal Scientist	Directorate of Sorghum Research (DSR), Rajendranagar, Hyderabad-500 030 (AP); India 040-24018651 Fax:040-24016378 ***Email:*** *dayakar@sorghum.res.in*	20.12.2007 to 31.03.2014	667.76
CCPI1	Dr. MP Rajendra Prasad, Deputy Director	National institute of Nutrition (NIN), Hyderabad	20.12.2007 to 31.03.2012	73.75
CCPI2	Mr. K Nirmal Reddy, General Manager	ITC Ltd. (Agri Business Division), Secunderabad	20.12.2007 to 31.03.2013	78.25
CCPI 3	Dr. TV Hymavathi, Assoc. Professor (Dr. Kamini Devi, Professor from 20.12. 07 to 31.08.10)	Acharya N.G. Ranga Agricultural University (ANGRAU), Hyderabad	01.09.2010 to 31.03.2013	61.50

CPI-Consortia Principal Investigator; CCPI-Consortia Co-Principal Investigator

12. Statement of budget released and utilization partner-wise (Rs in lakhs) upto

	CPI/ CCPI Name, designation & address	Total budget sanctioned	Fund released (up to closing date)	Fund utilized (up to closing date)
CPI	Dr. B Dayakar Rao, Principal Scientist, Directorate of Sorghum Research (DSR), Hyderabad	667.76	634.50	573.15
CCPI1	Dr. MP Rajendra Prasad, Deputy Director, National institute of Nutrition (NIN), Hyderabad	73.75	77.87	74.41
CCPI2	Mr. K Nirmal Reddy, General Manager, ITC Ltd. (ABD), Secunderabad.	78.25	68.20	67.47
CCPI 3	Dr. TV Hymavathi, Assoc. Professor, ANGRAU, Hyderabad.	61.50	62.07	60.82
Total		881.27	842.63	775.85

CPI-Consortia Principal Investigator; CCPI-Consortia Co-Principal Investigator

Part-II: Technical Details

1. Introduction

Millets are a traditional staple food of the rural poor in dry land regions of the country. In India, millets are grown on about 20 million ha with annual production of 18 million tons and contribute 10 % to the country's food grain basket. However, the direct consumption of sorghum and other millets as food has significantly declined over the past three decades. Monthly per capita consumption of sorghum declined from 1.2 kg to 0.33 kg in rural, whereas in urban areas from 0.6 kg to 0.22 kg during 1987-88 to 2005-06. In 2011-12, the monthly consumption of Sorghum was projected to decline to 0.32 kg in rural and 0.21 kg in urban areas. The decrease in demand has led to the decline in Sorghum production from 9.86 million tons in TE 1969-70 to 7.29 during TE 2009-10. The reason for the decrease in Sorghum consumption is that it is laborious and time-consuming to prepare food items. Further, the relative profitability of millets cultivation vis-à-vis other commercial crops is quite low due to lack of market assurance and timely farm extension services for intensive cultivation. Near-subsistence millets cultivation is characterized by low marketed surpluses, inconsistent quality and uncertainty in supply of grain. In absence of aggregation and storage functions, the supply chain management became major constraint. All these factors impeded the commercial uptake of the millet based food products. Obviously, industry was reluctant to go ahead in investing on millet foods production in the absence of continuous supply-chain.

Though the millet food products are known for nutrition, common people hardly know about their nutritional and therapeutic values. The health branding was not exploited enough to commercialize millet foods in the past, despite the fact that, millets are known to have rich composition of nutrients and minerals. This is mainly because of the absence of certification by competent national institutes and lack of awareness by the consumers and food industry alike. Further, professional market studies on consumer preferences and their potential in various segments of rural and urban markets are not really applied to focus on few products. Suggested measures as per consumer surveys of fine-tuning, packing, labeling, pricing are not scrupulously followed. This led to half-hearted efforts on targeting them as health and convenient foods. In fact, some attempts made have even failed though rarely reported. Even some isolated efforts made to popularize them could not catch up due to paucity of funds and consistent public support. Further, there are no integrated efforts to link up all the stakeholders in production to consumption system value-chain with assurance of critical mass efforts for this service. Moreover, due to disincentives resulting from Public Distribution System (PDS) for fine cereals and other practices, it has become necessary for reorientation of R&D efforts on millets to generate demand through value-addition. To augment such efforts, "Production to Consumption System" (PCS) model for specific products and markets are needed. The sub-project of NAIP-Millets Value Chain focuses on such an effort on selected millet foods with special case of sorghum; so that once the pilot project is successful it will be extended to other millets

2. Overall Sub-project Objectives

The present project focuses on such an effort focusing on selected millet foods by DSR (ICAR) led consortium.
The five objectives framed to be accomplished are:

1. To enable market-driven millets production for specific end-uses, procurement and primary processing for continuous supply-chain management.
2. Fine-tuning of the technologies for development of millet food products and upscaling.
3. Testing for nutritional evaluation and safety of selected millet foods.
4. Assessing consumer acceptability, price and market strategies, and social and policy imperatives.
5. Developing entrepreneurship and appropriate strategies to promote and popularize millets for commercialization through value-addition and branding as health foods.

3. Sub-project Technical Profile

Sl. No.	**Work Plan**	**monitoring indicators**	**expected output**	**expected outcome**
Objective 1: To enable on farm production, procurement and primary processing for supply-chain management of specific end uses.				
1.	Enabling on farm production of specific end used through technological back stopping.	No. of farmers benefited, farm income increased and risk for averted report.	1000 farmers/years e-choupal network provided intensive cultivation in millets with buy back.	Millet farmers are brought info e-choupal network and farm incomes increased by 10%
2.	Providing integrated farm extension services and farmers' training for intensive and profitable cultivation.	No. of farmers benefited, knowledge sharing events, number of people trained, video/film on	Holistic farm extension services produced through electronic media to 1000	Single window private public partnership model or integrated farm extension services enable

		package of practices	farmers/year for intensive cultivation.	in targeted millet crops.
3.	Facilitating grain procurement aggregation and storage function in target regions.	Quantity procured and aggregated and report.	700-1000 tonnes procured and aggregated to either store or sell based on market prices.	Continuous supply chain management for user industry and assured system of best market price to farmer.
Objective 2: Fine-tuning the technologies for development of millet food products and up scaling				
1	Fine-tune semi-processed, processed technologies for development of millet foods and retrofitting machinery.	No of identified food products fine–tuned, IPR, New products & prototypes.	Technologies for product development and refined for 5 identified millets foods, 2 prototypes per crop.	Inconveniences in preparations in millets are overcome in time conscious society & Ready to eat foods are available.
2	Upscaling the identified product(s) for wide spread markets & niche markets for promotion, popularization &marketing (in 2 diff. Channels).	Capacity upscaled, Number of market segments. These products are targeted, report	1 product for general markets, 3 for niche markets & 1 among non-conventional millet consumers.	Millets foods consumption increased by at least 5%
3	Standardize combinations of different millets for making multi-grain *atta* and gluten free for mass scale supply.	IPR, Report and prototype	Multi-grain *atta* as health food for mass consumption through large roti making machine	Increased millets foods consumption in urban & among social groups

Objective 3: To test for nutritional evaluation and safety of selected millet foods.				
1	Assessment of nutrient composition in selected millet foods.	Nutrient profile of semi-processed, processed & extruded products, report	Nutritional parameters assessed separately in 3 categories of millets foods	12 millet foods are labeled as health foods
2	Nutritional evaluation of the millet foods for diabetic and obese patients.	Subjects score, report	200 subjects evaluated in target group humans, nutritional qualification established, standards compared	Branding of millets as health foods for obese and diabetic groups.
3	Evaluation of semi-processed millets in mid-day meal program for nutritional characters.	No of students, report, growth in nutritional parameters	Increased health & nutrition of 120 students (6-12 yrs age) per each crop.	Millet based foods branded for nutrition & health among children and youth
4	Implementation of HACCP.	Safety standards, report, compliance, certification	12 products adjudged for safety standard compliance	Safety standards or meeting health & globalization standards
Objective 4: To assess consumer acceptability, price and market strategies, and social and policy imperatives				
1	Baseline survey	Benchmark of consumption, No. of products developed, No. of prototypes	Benchmark survey report for technologies	
2	Identification of number of potential food products for	Total number of foods, no of	One food product for	Millet foods catered to

	wide ranging and niche markets.	identified foods with potential market, market survey report	general market, 3 niche markets & 1 non-conventional market identified	different market segments appropriately.
3	Economic feasibility of products developed & studies on consumer acceptability & pricing strategies of millet foods	Benefit-cost analysis, Report, consumer preferences survey report	Pricing of products determined based on ROI & consumer acceptability survey results to help in modifications	Template for business plans available for bankable projects.
4	Sensitizing line departments of governments for enhancing millet consumption	Policy brief, price and consumption analysis and compared with other fine cereals report	Policy in favour of enhancing millet consumption as health & security enabled.	Millets becomes an important component in food security and nutritional security.
5	Assess socio-economic & environmental impacts of interventions for uptake plan.	Impact assessment report	Impact on socio-economic status of beneficiaries, stakeholders at every stage of value chain documented.	Positive impacts for replication of models.
Objective 5: To develop appropriate strategies to promote and popularize millets and innovative approaches for commercialization through value-addition and branding as health foods.				
1	Entrepreneurship development of stakeholders for intensive cultivation, product development, mechanization (on site and	No of stakeholders' trained Reports, knowledge sharing events and RLOs, demo	5 -6 thematic trainings/ workshops to stakeholders for capacity building in	Income of stakeholders increased by 10%

	through demo units).	kits.	activities on millets foods value chain	
2	Value addition through branding of millet based recipes as health foods by training and popularization.	Report, nutritional and safety certification, no of beneficiaries tested in schools, hostels, military canteens, No of exhibitions, melas, electronic media, print media (leaflets etc.)	Value addition through branding as health foods enabled. increased awareness through programmes and mass media , publications, video films, campaigns etc	Millet foods branded as nutritious and increased consumption
3	Innovative approaches for popularization of millets	No of innovative approaches, report, RLOs	Model millet dhaba established, millet tableaux, brand ambassador for millets	Mass awareness of millets foods and increased consumption
4	Assess socio-economic and environmental impacts of the interventions for uptake plan.	Impact assessment report	Impact on socio-economic status of beneficiaries, stakeholders at every stage of value chain documented	Positive impacts for replication of models.

4. Baseline Analysis

Over the four decades period sorghum area and production has declined due to unfavorable government policies coupled with changes in consumers' taste and preferences for ready-to eat/cook and convenient foods for which sorghum lacks desired attributes. The decrease in sorghum consumption is mainly due to laborious and time-consuming process involved in preparation of food, and also the policy of the government to supply fine cereals at subsidized prices. Further, the relative profitability of sorghum cultivation vis-à-vis other commercial crops is quite low due to lack of market assurance and timely farm extension services for intensive cultivation.

Processing interventions were not tried enough to create value-addition in sorghum since there were no specific machinery available in the market for sorghum processing. There was also negative perception on the part of the entrepreneurs not willing to take up sorghum processing due to its low shelf life, which is crucial for marketing the products. Besides, the research institutes worked independently and were not market driven. Consequently, suitable processing grade varieties of millets and technologies remained on the shelves of the research laboratories due to lack of proper institutional mechanism. Millet foods are not significantly exploited to commercialize their importance as health or prophylactic food, despite offering well-balanced composition of carbohydrates, proteins and minerals together with high dietary fibre.

To establish benchmarks for on-farm kharif and Rabi sorghum production in the targeted districts base line survey was conducted under NAIP sub-project on "Creation of demand for millet foods through PCS value-chain". The parameters of the survey are on-farm situations on sorghum cropping pattern, production, market information, daily consumption, income and expenditure, etc. To implement this project Andhra Pradesh (kharif) and Maharashtra (*rabi*) states were selected on the basis of sorghum area and production. Further Adilabad district from Andhra Pradesh and Parbhani district from Maharashtra were selected purposively. Hence, the baseline survey was conducted in Adilabad district, Andhra Pradesh, and Parbhani, Maharashtra purposively.

a. Important base line indicators for sorghum status – Adilabad and Parbhani districts

S. No	Indicators	Adilabad	Parbhani
		Baseline Status (2008)	Baseline Status (2008)
1.	**Farmer (Sorghum)**	Nil	Nil
	a. Education i) Number of literates/ illiterates	58% literates and 42% illiterates	87% literates and 13% illiterates

S. No	Indicators	Adilabad	Parbhani
		Baseline Status (2008)	**Baseline Status (2008)**
	b. Total land		
	i) Sorghum area	19.40%	30%
	ii) Other crops area	80.60%	70%
	c. Input utilization(kg/acre)		
	i) Seed	3 kgs	4 kgs
	ii) Manure	1.25 tonnes	1.73 tonnes
	iii) Fertilizers	35 kgs of DAP+10 kgs of Urea	50 kgs of DAP+15 kgs of Urea
	iv) Insecticides	0.5 kgs	0.1kg
	d. Farm productivity (q/ha)		
	i) Stalk	28.75	22.35
	ii) Grain	14.37	14.20
	Resource characterization		
	i) Soil type	Black soil	Black soil
	ii) Irrigation availability	40% of area	44% of area
	e. Income of household/family(per annum)	Rs. 53290	Rs. 63190
	i) Agriculture	Rs. 40550	Rs. 37514
	ii) Non-Agriculture	Rs. 12740	Rs. 25676
	f. Employment available		
	a) On-farm		
	i) Male	90	98
	ii) Female	150	143
	b) Off-farm		
	i) Male	45	53
	ii) Female	15	37
	g. Total Cost of Production(Rs/acre)	Rs. 3746.56	Rs. 3188.91
	h. Market surplus of sorghum	24.48% 546.27 q	30.76% 1665 q

S. No	Indicators	Adilabad	Parbhani
		Baseline Status (2008)	**Baseline Status (2008)**
	i) Total production	41.80%	37.75%
	ii) For family consumption	13.85%	13.35%
	iii) Consumption by permanent labour and temporary; labour	0	0.45
	iv) For seed purpose	0.53%	0.53%
	v) For animal feed	19.34%	17.16%
	vi) For payment in cash and kind		
	i. Consumption of cereals (per day/meal)		
	i) Paddy	1	0.25
	ii) Wheat	1	1
	iii) Maize	0	0
	iv) Sorghum	1	1.5
	v) Proportion of sorghum to total cereals	40%	45%
	j. Utilization of sorghum/pearl millet	1 kg	1.5 kg
	i) Food (per day)		
	ii) Non-food uses		
	iii) Fodder		
	iv) Other by products at farm level		
2	**Farmers knowledge**		
	a. Package of practices		
	i) Seed treatment/sowing	25%	35%
	ii) Ploughing/ soil preparation	50%	56%
		40%	47%
		35%	35%

S. No	Indicators	Adilabad	Parbhani
		Baseline Status (2008)	**Baseline Status (2008)**
	iii) Fertilizer composition	15%	25%
	iv) Pest control	15%	23%
	v) Harvesting technology		
	vi) Procurement		
	k. Marketing channel of produce?		
	i) Local buyer	85%	28.73%
	ii) Nearest APMC	0%	71.27%
	iii) Agent at larger *mandis*	0%	0%
	iv) Middlemen	0%	0%
	v) Fellow farmers	15%	0%
	vi) Others (Specify)	0%	0%
	l. Distance of marketing place (kms.)	10	8
	m. Market prices(per quintal)		
	i) Local market	Rs. 670	Rs. 775
	ii) Wholesale market	Rs. 690	Rs. 783
	iii) Retail market	Rs. 700	Rs. 825
	n. Infrastructure		
	i) Farm house	Nil	Nil
	ii) Godown	Nil	Nil
	iii) Warehouse	Nil	Nil
	o. Extension services		
	i) Public institutions	KVK Adilabad, Utnoor and Gudihathnoor	MAU, Parbhani
	ii) NGOs/ Private	BASICS, Adilabad	Nil
	p. Current policy		

S. No	Indicators	Adilabad	Parbhani
		Baseline Status (2008)	**Baseline Status (2008)**
3.	**Procurement (Buy-back) (Sorghum)**		
	a. Existing institutions and agencies	ITC Ltd	ITC Ltd
	b. Quantity procured/ area covered	nil	Nil
	c. Storage mode/ method of storage i) Domestic storage (storage binds/stacks, etc.) ii) Commercial storage (Cold storage/warehouses) iii) Packing in gunny bags iv) Others (Specify)	65% 35%	93% 7%
	d. Quality standards	Nil	Nil
	e. Problems/constrains in procurement	Blacken the grain and insecticides	Nil

If there is a good market demand and premium price for the commodity in the market, nothing could stop the farmers from cultivating the sorghum. However, under the existing situation, either the yields or market price of sorghum could not be compared with cotton or soybean, the major rain fed crops which are cultivated as major commercial crops in the study area. Near-subsistence sorghum cultivation is characterized by low marketed surpluses, inconsistent quality and uncertainty in supply of grain. In absence of aggregation and storage functions, the supply chain management became a major constraint. All these factors impeded the commercial uptake of the millet based food products.

5. Research Achievements

Summary

- On farm (end product specific) intervention in PPP mode with ITC (ABD) Ltd: The impact of the subproject is evidenced through a change in mindset of sorghum farmers as they opted to allocate better lands for sorghum cultivation over past four years owing to higher returns from its cultivation.
- Technological backstopping with end-product specific improved sorghum cultivars up on PPP mode - M 35-1, CSV 216R, Parbhani Moti, Phule Vasudha and Phule Revati in rabi season and CSH-14, CSH-16, CSH 23, CSV 20 and SPH 1148 during Kharif, with extension services and buy-back assurance among the 1500 sorghum beneficiary farmers in Adilabad Nanded (kharif), Parbhani (rabi) in 1500 acres each year. It has resulted in the increase in average income in kharif season by 222 % and 69 % in rabi season over baseline.
- 500 processing clusters/ beneficiaries on primary and secondary processing machinery technologies across millet growing states under DAC's INSIMP programme are technologically backstopped by NAIP Millets value chain led by DSR.
- Three states of Maharashtra, Karnataka, and AP have launched supply of millet foods on pilot scale in one district each in January, 2013 which is again an offshoot of NAIP Millets value chain policy sensitization.
- Establishment of Centre of Excellence (CoE) on value addition & food processing at DSR which has been serving as nodal centre on showcasing technologies and entrepreneurship development apart from its routine R&D activities on product development & standardization.
- Successfully commercialized 7 sorghum based product technologies on pilot scale under DSR's eatrite brand *'EATRITE',* now marketed through Heritage fresh retail outlets in Hyderabad. Many other instant foods are in pipeline.
- Horizontal expansion is initiated to launch *eatrite* products in Delhi, Pune and Mumbai
- "ANGRAU foods" a trade mark is also registered by our partner ANGRAU to commercialize sorghum crispies, biscuits etc.
- Processing interventions led to removal of inconveniences in preparation of traditional rotis offering health conscious urban consumers a wide range of choice of healthy and convenient RTC/E foods. More technologies especially in instant foods segment are in pipe line.
- DSR has retrofitted 30 machineries to make them suitable for sorghum processing.
- Nutritional testing and evaluation has been done by NIN, Hyderabad on sorghum and establishing with scientific data on Glycosilated haemoglobin control due to sorghum

food effective in the control of glucose among the diabetics. Further, corroborating it with the data generated on glycemic index and load

- Successful in establishing and innovating nutritional superiority of sorghum diet for diabetics, school children with a rich composition of minerals and vitamins over their cereals such as rice and wheat.
- Outsourcing of popularization with innovative models to create awareness on nutritional superiority with improved communication strategies. Innovative marketing strategies used to commercialize Eatrite products
- An MoU is signed with a multi-national company i.e., M/s Britannia (first time in the history of ICAR) by DSR to work jointly on R&D on bakery and biscuit products.
- Signed MoUs with atleast 10 private entrepreneurs under various business plans for commercialization of Sorghum processed foods in Hyderabad
- Farm level value addition efforts resulted in manifold increase in the net income of farmers. A farmers group is formed in Tadkalas village to undertake value-addition business in Sorghum.
- More than 4000 Farmers, SHGs, Small scale processors, Women groups, rural entrepreneurs are trained in Sorghum processing as a separate channel through Entrepreneurship development programmes.
- Many rural industries (more than 100 processing clusters) are established.
- Sensitization of Policy makers through road shows in public parks & Malls such as Reliance Fresh, Food bazaar, Choupal fresh etc using Jowar Rath- mobile van to create awareness on nutritional superiority including those policy makers to initiate 300 crore INSIMP initiatives by DAC.
- Great emphasis is given to DSR's millet promotion by DAC under INSIMP. This is primarily due our successful NAIP model tested at Hyderabad to create demand for sorghum through processing & commercialization.

A. Identification of cultivars for specific end-products from land races or other germplasm lines

1. Identification of cultivars/genotypes for specific end products

The physical grain attributes of sorghum especially grain size, grain weight, endosperm texture and grain hardness are the important traits that affect the end use quality of sorghum. About 400 genotypes were tested for four physical grain traits (grain size, grain weight, endosperm texture and grain hardness). Among the various grain types, 20 genotypes with bold grain size suitable for poha and pops, 106 genotypes with corneous endosperm suitable for coarse semolina preparation, 18 genotypes superior for grain size and weight and floury endosperm suited for roti and other bakery products like cake and biscuit, 25 genotypes superior for grain weight, grain

size and intermediary endosperm suitable for fine semolina and cold extruded products (pasta and vermicelli) were identified. The released varieties were tested for its suitability for various end products and the genotypes/cultivars more suited for specific end products is given below.

Table 1 : Genotypes with superior popping ability

S.No	Genotypes	Weight after soaking	grain weight before popping	% Popping ability
1	Dagadi	505	200	60.4
2	**CSV 216R**	**420**	**100**	**76.2**
3	M35-1	560	280	50.0
4	DSV-5	570	170	70.2
5	**PKV-kranti**	**500**	**105**	**79.0**
6	CSV-22	440	200	54.6
7	**CSV-18**	**515**	**80**	**84.5**

Table 2: Genotypes/cultivars with high semolina recovery

S. No	Genotype	100 seed weight (g)	Grain hardness (sec)	Semolina recovery (%)
1	RS 627	2.438	61.2	41.5
2	RS 673	2.476	81.7	44.2
3	CSV 13	2.966	84	43.2
4	CSV 15	3.414	65	44.3
5	SPV 462	3.506	68.7	38

Table 3: Cultivars suited for flour making

S. No	Cultivar	Grain Lustre	Size of mark of germ	Texture of Endosperm	Grain hardness (sec
1	CSV 18R	Lustrous	Large	¾ farinaceous	16.5
2	CSV 22R	Lustrous	Medium	¾ farinaceous	15.5
3	CSV 216R	Lustrous	Medium	¾ farinaceous	19.5
4	PKV Kranthi	Lustrous	Medium	¾ farinaceous	17
5	Phule Revathi	Lustrous	Medium	¾ farinaceous	15.5

2. Identification of stable lines with high protein digestibility for improvement of grain quality in sorghum

The protein quality is an important aspect for determining the nutritional quality of sorghum. Among protein quality, protein digestibility is an important nutritional trait that enhances the value of sorghum for food. The protein digestibility in most of the sorghum genotypes were in range of 40 – 50%. The objective of the present study was to identify stable lines for protein digestibility. Forty nine elite sorghum genotypes were evaluated for protein digestibility and related grain quality traits. Turbidity assay for rapid identification of high protein digestible lines were used to screen the test genotypes. Wide range of variability was observed for this grain protein digestibility ranging from 25.15 (27B) to 69.7 % (SPV 1775) but the hybrid parental lines of the released hybrids showed low variability for grain protein digestibility indicating significant scope for its improvement. The genotypes SPV 1775 (69.7), SPV 1758 (65.2), SPV 462 (65.39%) and Sakkari Mukri (64.45%) were found to have high grain protein digestibility. The identified lines (SPV 1775, SPV 462) with high protein digestibility are crossed with the existing parental lines (296B, 27 B, NR 486, RS 627, AKR 150, C 43) of hybrids for development of new hybrid parental lines with superior grain protein digestibility. The newly developed lines are in advanced stage (F4) stage of generation advancement. At F6 stage of generation advancement, the lines will be evaluated for protein digestibility and grain quality tested as well as tested for its suitability for using it in hybrid development.

In addition to protein digestibility, we attempted to study the amino acid profile of sorghum cultivars. Quality proteins are readily digestible and contain essential amino acids in quantities required by human beings. Grains of most cereals including sorghum are said to contain inadequate levels of essential amino acids especially lysine followed by threonine, tryptophan and methionine. Breeding for improved amino acid composition has been attempted in cereals and commercially exploitable high lysine varieties are now available in maize while there are no commercially available high lysine cultivars in sorghum. To breed sorghum lines with superior protein quality through improving the essential amino acid composition, it is necessary to understand the amino acid profile in our released cultivars. The analysis was done using the Near Infra Red Spectroscopy (NIRS) method as per the calibrations developed by Evano feed industries. Cultivar wise amino acid content for each of the five rabi sorghum cultivars along with range and mean is given in Fig.

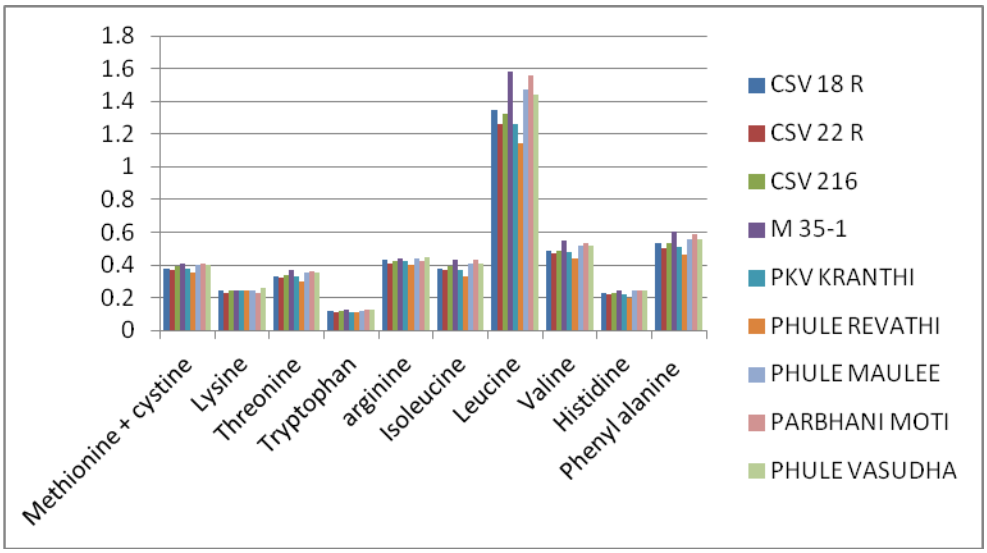


Fig 1: Amino acid profile of the rabi sorghum cultivars

Among the various amino acids, high levels was observed for leucine, phenyl alanine, valine and arginine while tryptophan, cystine, methionine and lysine showed low levels. Wide range was observed among the cultivars for leucine, isoleucine, valine, phenyl alanine, threonine and arginine while low variability was observed for lysine, methionine, tryptophan (limiting amino acids). Among the nine cultivars tested M35-1 and Phule Vasudha were superior for most of the amino acids tested. For lysine which is the the most limiting amino acid, Phule vasudha recorded 0.26 % as against 0.18 -0.21% which is generally reported in sorghum. Scientists from Purdue University have reported sorghum lines with high lysine content. A high lysine sorghum mutant P721Q was reported to have obtained by chemical mutagenesis of normal line P721N. Subsequently P851171 and P850029 were developed from P721Q with superior protein quality. These results indicate scope for utilization of high lysine sorghum lines for improving protein quality in sorghum. Further, large scale indigenous germplasm will be screened for identification of high lysine lines for its use in breeding programmes.

3. Variability and correlation analysis for grain quality traits in sorghum.

Forty two elite genotypes and cultivars were tested for biochemical characters line fat (%), protein (%), starch (%), phytic acid (mg/100mg), Amylose (%) and protein digestibility (%). The variability for these parameters are given in the table below. High variability observed for the traits indicates its usefulness for selection of genotypes for specific end uses. Among the grain quality traits studied, high variance was observed for protein digestibility, followed by amylose and starch content. Further to establish association among different grain quality traits correlation coefficients were calculated. We did not observed any significant correlations among the grain quality traits except amylose (%) with phytic acid (mg/100mg).

Table 4: Variability and correlation analysis for grain quality traits in sorghum

Parameters	Fat (%)	Protein (%)	Starch (%)	Phytic acid (mg/100mg)	Amylose (%)	Protein digestibility (%)
Min	1.94	7.46	54.7	2.4	8.35	40
Max	3.5	13.8	72.5	6.7	20.96	67.1
Mean	2.68286	9.73024	64.1405	4.4119	14.08	47.7076
Variance	0.113826	1.39201	13.2748	1.44888	12.58	43.0887
SD	0.337381	1.17984	3.64346	1.20369	3.54	6.56419

Table 5: Correlations coefficients for grain quality traits

Parameters	Fat (%)	Protein (%)	Starch (%)	Phytic acid (mg/100mg)	Amylose (%)
Protein (%)	-0.13				
Starch (%)	-0.18	-0.06			
Phytic acid (mg/100mg)	0.04	0.02	0.09		
Amylose (%)	0.05	0.01	0.08	-0.26*	
Protein digestibility (%)	-0.07	0.09	-0.04	0.17	-0.03

B. On-farm technological backstopping with end products specific cultivars/hybrids and facilitation of procurement (DSR & ITC)

Fig 2. Rabi Season: Farmers' Orientation & Farmers' Field

Fig 3. Kharif Season: Farmers' Orientation & Farmers' Field

A four year study was conducted during *kharif* of which two years were (2008 and 2009) in Adilabad, Andhra Pradesh and the next two years (2010 and 2011) in Nanded, Maharashtra and during *rabi* in Parbhani, Maharashtra from 2008-09 to 2011-12. Baseline survey was conducted in these districts before starting the project with 100 farmers (25 farmers in each village) selected, so as to establish benchmarks for impact analysis of the interventions executed in this pilot scale value chain on sorghum foods. From each selected district, 500 participating farmers covering 20 e-*choupals* were identified under different landholding categories and each farmer was provided with 3 kg of seed of improved cultivars (CSH-14, CSH-16, CSH-23, CSV-20 and SPH-1148 in *kharif* and M 35-1, CSV 216 R (Phule Yashoda) & SPV 1411 (Parbhani Moti), Phule Vasudha and Phule Revati in *rabi*). Thus, a total of 1000 farmers were brought under 400 ha in an year.

The end-product specific on-farm production was facilitated on the lines of successful models of ITC's *e-choupal*. In this model, farmers were given market buy-back assurance for (Fairly Accepted Quality) FAQ grain (In case if they do not find a market or appropriate price, ITC will procure and is aggregated from small holder's marketed surplus). ITC-ABD facilitated integrated farm extension services in private-public partnership (PPP) mode on procurement, extension, dissemination of knowledge and information including daily market prices in various markets through the computers placed in *e-choupal sanchalak's* (village representative) house which is accessible to all the participating farmers in the village. The procurement of participating farmers' produced through buy-back mechanism, and sharing the knowledge are either facilitated or undertaken directly by ITC Ltd.

Table 6: Economics of the participating sorghum farmers from 2008- 2011

Kharif						
Year	Cost of cultivation	Grain Yield (Kg/ha)	Stalk Yield (Kg/ha)	Gross returns	Net returns	Output-input ratio
Baseline (Adilabad)	8830	1418	7188	15309	6479	1.73
2008	11975	1107	4264	18939.37	6964	1.59
% +/- over baseline	36%	-22%	-41%	24%	7%	8%
2009	11272	1391	4640	24783	13511	2.19
% +/- over baseline	28%	-2%	-35%	62%	109%	27%
Baseline (Nanded)	12956	1796	6604	19008	6052	1.47
2010	11387	2270	0473	30085	18698	2.64

% +/- over baseline	-12%	26%	59%	58%	209%	80%
2011	12687	2743	10697	54257	41570	4.28
% +/- over baseline	-2%	53%	62%	185%	587%	191%
RABI						
Baseline	7972	1420	5588	23234	15262	2.91
2008	10302	1597	6478	33174	22872	3.22
% +/- over baseline	29%	13%	16%	43%	50%	11%
2009	12624	1612	5610	33796	21172	2.68
% +/- over baseline	58%	14%	0.39%	46%	39%	-8%
2010	11241	759	5234	38535	27294	3.43
% +/- over baseline	41%	-47%	-6%	66%	79%	18%
2011	19217	1952	5960	51146	31929	2.66
% +/- over baseline	141%	38%	7%	120%	109%	-9%

Sorghum yield in kharif season

The intensive *kharif* sorghum production experienced a decrease in grain and stalk yield by 21.93% and 40.68%, respectively in 2008 (Table.1). In 2009, the grain yield and stalk yield decreased again by 1.90% and 35.45% respectively. In the third year, the Kharif sorghum on-farm production was shifted to Nanded in Maharashtra, since the ITC has well established e-Choupal network there. Therefore, intensive *kharif* sorghum production in Nanded resulted to increase in grain yield and stalk yield by 26.39% and 58.58%, respectively in 2010. Further, in 2011 the grain and stalk yield were increased by 52.73% and 61.98%, respectively. During these two years, the seeds (CSH 16, CSH 14 & SPH 1148) provided in Nanded were found very suitable. The farmers followed recommended package of practices given by the DSR during the orientation programmes. This resulted to tremendous increase in grain and stalk yield.

Sorghum yield in rabi season

The use of improved cultivars increased grain and stalk yield to the tune of 12.46% and 15.93% and reached 15.97 q/ha and 64.78 q/ha respectively during 2008-09. During 2009-10, grain yield was increased and reached 16.12 q/ha whereas the stalk yield was lower (56.10 q/ha) than the previous year, though more than the baseline. Yields were increased by 16.12% and 56.10%, respectively over baseline in the second year. In 2010-11, yields were decreased over baseline to the tune of 46.55% and 6.33% to 7.59 q/ha and 52.34 q/ha respectively due to heavy fog and extremely cold weather during the crop growth effecting almost all the crops in the entire region. In 2011-12, grain and stalk yields showed upward trend and reached to 19.52 q/ha and 59.6 q/ha, respectively with increase to an extent of 37.46% and 6.66%, respectively over baseline.

Economics of farmers in kharif season

The cost of cultivation and gross returns were slightly higher than baseline (8830 and 15309, respectively) in 2008 where it was Rs.11975.37 and Rs.18939.37, respectively and in 2009 it was Rs.11271.84 and Rs.24782.84, respectively. However, net returns were slightly higher than

baseline in 2008 (Rs.6964) whereas, in 2009 (Rs.13511) it was double to the baseline income (Rs.6479).

Cost of cultivation was decreased in 2010 and 2011. Gross returns, net returns and output-input ratio were increased at an exceptional rate by 58.27%, 208.95% and 79.59% respectively in 2010 and by 185.43%, 586.86% and 191.16 %, respectively in 2011 over baseline. The net returns in 2011 (Rs.41570) doubled the net returns in 2010 (Rs.18698).One important aspect of intensive cultivation was the increase in income despite not much encouraging grain yields. It was due to assured and higher market output price even for the *kharif* produce.

Economics of farmers in rabi season

With the use of improved cultivars, net returns were increased over baseline during *rabi* to the tune of 49.85%, 38.72%, 78.8% and 109% during 2008-09, 2009-10, 2010-11 and 2011-12, respectively. During 2008-09, the sorghum economy showed a positive impact on net returns (Rs.22871.51) and reached output-input ratio of 3.22. During 2009-10 the economy continued to gain positive results, though the net returns (Rs.21171.93) were less than the previous year (2008-09) owing to less stalk yield inspite of marginal increase in grain yield from the first year and the output-input ratio was 2.68. Whereas, net returns were doubled during 2010-11 (Rs.27293.52), 2011-12 (Rs.31929) over baseline and output-input ratios were 3.43 and 2.66, respectively.

Thus, it could be inferred that there was an increase in the net returns of the *rabi*participating farmers over baseline incomes. Also, the assurance of buyback gave motivation to the participating farmers to employ gainful crop management practices which led to higher income. In fact, the income of those participating farmers whose produce was procured, increased by 44 per cent over the baseline income, while those whose produce was not procured, income increased by 36 per cent. From the study we could infer that sorghum when cultivated on an intensive scale with backstopping of technology and farm extension services impacted yield and income levels. The end-product specific production also had another advantage of linking up with entrepreneurs who actually bought the identity preserved produce which was procured and aggregated for engaging in small-scale production of specific sorghum products.

Comparison of *kharif* and *rabi* yield and economics

From Table 1 it can be inferred that grain (18.78 q/ha) and stalk (75.18 q/ha) yields of *kharif* are more than *rabi* (14.8 q/ha and 58.2 q/ha, respectively) and the average grain yield and stalk yield recorded during four years of the project was 16.79 q/ha and 66.69 q/ha, respectively. But, the net returns incurred during *kharif* are less when compared to *rabi* because the price of the grain during *kharif* was less due to its inferior quality as a result of molding due to heavy rainfall at the time of harvesting and so it was unfit for consumption. The net returns were increased from year to year in both the seasons. Kharif net returns were directly related to yields and increased linearly from year to year as the yields were increased. Price of the commodity showed a positive increase from 2008 to 2009 but a slight decrease in price was observed during 2010. Even

though the price was decreased, net returns were increased because of an increase in yields. In 2011, highest yields were recorded with more prices and fetched maximum net returns. In case of rabi, the price was inversely related to yield as it showed positive trend from 2008-09 to 2011-12 and then it declined. Net returns showed a slight decrease from 2008-09 to 2009-10, whereas it increased from 2009-10 and recorded highest during 2011-12. Even though price decreased, yield was highest during 2011-12 so that maximum net returns were fetched.

Factorization of income from on- farm sorghum production

The average increase in net income (two seasons) amounted to 138 % over the baseline income (Table 2). In other words, the average income of participating farmers was Rs 12798/ha when compared to Rs 9265/ha of the benchmark data. The table further reveals that the incremental income of *rabi* farmers exceeds *kharif* farmers in absolute numbers while actually the percent increase over baseline is reverse due to a low baseline *kharif* net income compared to the *rabi* income.

Table 7: Factorization of income from on- farm sorghum production

S. No.	Parameters	Net income (Rs/ha)
I	**Benchmark data**	
A	*Kharif* 2007	6480
B	*Kharif* 2009	6052
C	*Kharif*	6266
D	*Rabi* 2007	15262
A	**Average (c & d)**	**9265**
II	**Actual on-farm production (*Kharif* & *Rabi*)**	
E	Average of *kharif* 2008 & 2009	10237
F	Average of *kharif* 2010 &2011	30134
G	Average of *kharif* 2008,2009,2010&2011	20186
H	Average of *rabi* 2008-09, 2009-10, 2010-11 &2011-12	25817
B	**Average (g & h)**	**22063**
C	**Incremental Net Income in *kharif* over baseline (g-c)**	**13920 (222%)**
D	**Incremental Net Income in *rabi* over baseline (h-d)**	**10555 (69.16%)**
	Average incremental net income over baseline (B - A)	**12798 (138%)**

With buy back assurance given to the farmers, almost all the farmers followed recommended package of practices though obviously there were some constraints in the procurement of the inputs required. Price of sorghum increased year by year and the market price could be assured to farmers through buy back assurance. This is the first time they have concentrated on sorghum and spent much time in adopting all the practices. They never knew that sorghum also can have these many alternative uses. By knowing all food products prepared from sorghum and the impact of adopting the recommended practices, farmers are now enthusiastic about the sorghum crop and want to continue the same kind of practices in future also. Earlier farmers use to grow sorghum in marginal lands but now they are growing sorghum in fertile lands. It is also important to note that, under the sub-project, the ITC merely opted consultancy charges but mainly targeted at bringing higher returns to the farmers by negotiating on behalf of farmers as a whole for receiving maximum consumers' price for their grain.

C. Impact of farm level value addition (DSR & ITC)

Emphasis has always been on the remunerative returns to the farmers through possibility of value addition, which has been instilled in the farmers' minds through various approaches. Demonstrations were held for harvest at right physiological maturity and drying (both natural and mechanical drying processes) particularly in Kharif season to avoid quality deterioration and mould formation. Innovative 360 degree communications were leveraged to create awareness on value addition. At every farmers meet, value added Jowar products were displayed. Training programmes were conducted involving women farmers, women SHGs and rural entrepreneurs on value addition and nutritional aspects of jowar food products.

A mini demo processing plant comprising of a dehuller, parboiling unit and flaking unit machine was commissioned in Borisawant village of Parbhani district, which were purchased under the NAIP subproject for exploring commercial opportunity and feasibility at farm level. This helped in popularization of Sorghum products to many other Choupals' in the Parbhani district. Farmers are utilizing it for planning further business investments plans. A farmers group is formed in Tadkalas village to undertake value-addition business in Sorghum.

Fig 4: Sorghum mini processing unit and women entrepreneurship development programme

Sorghum mini processing unit and women entrepreneurship development programme

Earlier the participating farmers sold the entire surplus in their local market, however, under the intensive cultivation their produce are now either procured by the ITC (ABD) Ltd. at the ideal price or the farmers themselves produce them into flakes or rawa from the sorghum processing demo unit which was established at Borisawant village. Their incomes have doubled to Rs. 2000 to 3000 per quintal excluding by-product value, which they earlier sold at maximum Rs. 1000/Qtl as grain. This is possible since the farmers are directly linked up with the processors for

the FAQ grain. The economics of up-scaling plans for sorghum processing at farmer entrepreneurship level is shown in table below:

Table 8: Economics of up scaling plans at Farmer –Entrepreneur level

Efficiency levels	Cost of production at various capacities in Rs/kg			
	50 kgs/day	100 kgs/day	200 kgs/day	500 kgs/day
50 % Recovery	33.32	25.34	22.65	21.56
60 % Recovery	28.67	22.12	19.88	18.97
70 % Recovery	25.44	19.82	17.89	17.11

Normally per kg of grain fetched a profit of Rs 10.00, value addition improved the profit to Rs 18.00. This is going to increase as we upscale, if the capacity is doubled the cost per kg would be Rs 17.00 and the value addition would fetch up to Rs 23/ kg. Farm level consumption of Jowar products also increased due to creating awareness on Sorghum nutrition and processing (convenience foods).

Besides these, farmers are encouraged to take up small scale processing and simultaneously linking them with the financial institutions, another major stakeholder under the PPP model of sorghum value chain.

D. Processing Interventions

One of the major reasons for decline in the consumption of millets is due to the inconvenience in its product preparation. Under this project, processing interventions were attempted to remove the inconveniences by developing and standardizing sorghum and pearl millet product technologies. For this purpose, the DSR and ANGRAU has installed and retrofitted machineries under NAIP fund.

At ANGRAU, pearl millet products such as pearl millet flour, multigrain flour, semolina and RTE extruded snacks were developed. Shelf life of pearl millet and flour was evaluated using different packaging material and irradiation. Sorghum products such as multigrain roti (2 types), multigrain flour, biscuits (14 varieties; salt, sweet, groundnut, coconut, gluten free salt and sweet biscuits, trans fat free salt, sweet, groundnut and coconut and low calorie salt, sweet, ground nut and coconut), RTE extruded snacks, gluten free crunches, gluten free pasta (3 varieties; soy, caseinates, flax seed incorporated) and designer rawa which is rich in resistant starch were developed. Shelf life for multigrain flour was extended using hurdle technology.

At DSR, suitable genotypes for food processing and storage period of sorghum grains were evaluated. Sorghum products were developed using different technologies such as soaking, malting, dehulling, parboiling, milling, baking, flaking, fermentation, and extrusion cooking. Dehulled sorghum, sorghum flour, multi grain flour, coarse, medium and fine semolina, parboiled semolina, flakes, vermicelli and pasta, biscuits (gluten free, trans fat free, and cocoa),

protein rich snacks, chocolate fur cake, pure sorghum cake, and lassi (sweet and salt) were developed and standardized. Studies were conducted for the extension of shelf life of sorghum rich multigrain flour using different packaging materials and suitable packaging material has been used for commercialization. Technology was developed for pasta taste maker to ease the cooking of sorghum pasta. Technologies are also available at DSR for instant foods such as idli, dhokla, upma, dosa , pongal, vermicelli kheer mix, flakes kheer mix, pedha and masala sorghum flakes and pops (2 types, aam chat masala, pudina masala). Products such as sorghum pedha, bran soup, bran pedha using byproducts of sorghum. More than 30 recipes were developed and standardized at DSR. The acceptability of some products was either on par or better than on-shelf products made from other cereals. AT CFRTI, shelf life of sorghum flour was assessed using infrared heating and sorghum pasta was developed.

Processing of pearl millet

The outer bran in coarse grains is fibrous, bitter, astringent, or coloured. Removal of the coarse seed coat is therefore desirable to confer adequate consumer acceptability to them. Dehulling at a desirable level improves the flour quality and makes it amenable to certain products like biscuits, pasta and bread etc. Dehulling of pearl millet was done with retrofitting the machine, narrowing the distance between the abrasive stones as pearl millet grains are smaller in size than sorghum grain. The time and percent dehulling of the grain was found optimum at 17% dehulling. Less than or above 17% of dehulling resulted in either more undehulled grain or excessive pearling leading to loss of endosperm. Several trials were carried out to obtain optimum percentage of dehulled pearl millet grain and the observations are as given below.

Parameter	**Value**
Quantity of grain used for dehulling	5 kg
Time of dehulling	20 minutes
Yield of grain	4.145kg
Husk from the grain	852 g
Husk %	17.04

Pear millet products

Flour and semolina were prepared from the dehulled grain using domestic flour mill (NISA make) of 5 Kg capacity. The following yields of flour, fine rawa and coarse rawa were obtained when grain was milled for flour or rawa. The separation of these products was done using standard sieves. The results are tabulated in Table 8.

Table 9: Percent yield of pearl millet products

Item	Yield of the product (%)						Flour mill (plate No)
	Flour	**Fine semolina**	**Coarse rawa**	**Medium rawa**	**Wastage**	**Standard sieve**	
Flour	86.6	13.4	-	-	1	40,60	1,0 no
Fine Semolina	35	63	1	-	1	60	4 no
Coarse rawa	15.5	38.18	38.18	-	4.84	14 mesh	3 no

Studies on effect of various treatments on the shelf life of pearl millet grain

In order to enhance shelf life of the grain, various treatments were given and the treated samples were stored for 90 days under ambient conditions in three different containers viz., plastic jar (PJ), plastic gunny bag (PG) and metal can (MC).

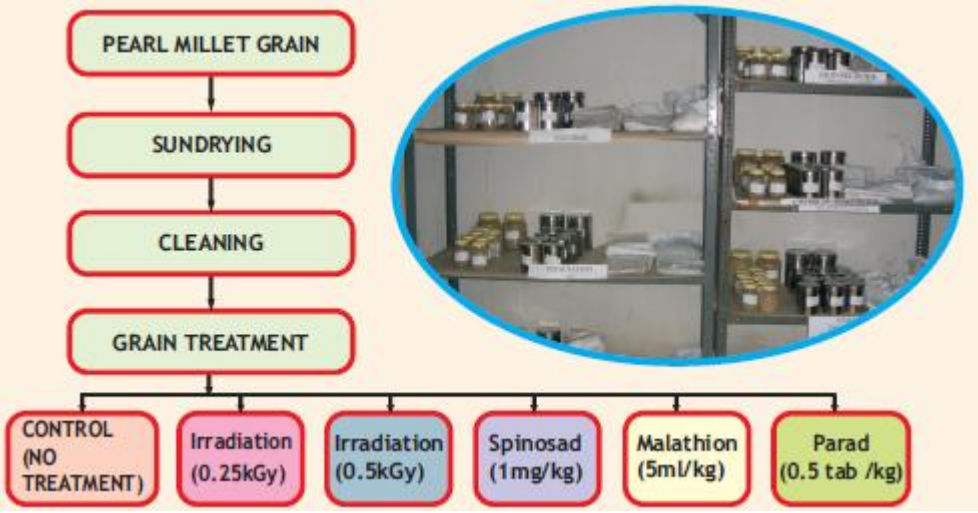


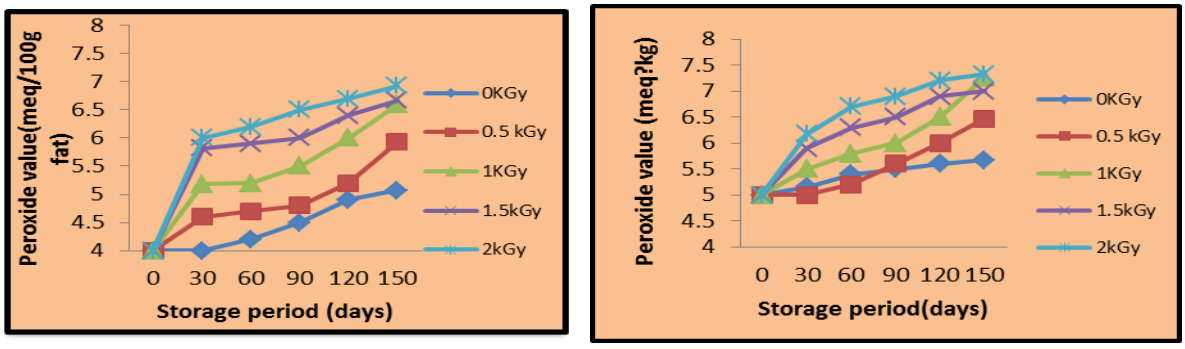
Fig 4: Flow chart showing the methodology for storage study

Pearl millet grain was treated with various insecticides and irradiation at two levels (0.25kGy and 0.5 kGy) and the stored grain samples were analyzed for grain hardness, 1000 grain weight, fat acidity, bacterial count and uric acid content. The moisture content of pearl millet ranged from 11.0 to 14.8 before and during the storage period of three months. Irrespective of the insecticide treatment, pearl millet grains registered significant loss in 1000 grain weight after 60 days. The percent loss was lower (0.62%) in spinosad treated grain followed by Parad (1%), Malathion (2%), irradiation at 0.5Kgy (14%) and irradiation at 0.25% (16%). The pearl millet grain stored in jars did not undergo any significant change in grain hardness ((p=0.05) up to 45 days of storage, whereas grain stored in plastic gunny and steel cans retained only up to 30 days after which softening of grain was initiated. Spinosad, Malathion and Parad treatments were significantly better in maintaining grain hardness. All the treatments except irradiation @0.25 KGy were found to control the development of fat acidity. Spinosad and Malathion were significantly more

effective than Parad and irradiation (0.5KGy). These treatments were thus found to arrest the rate of increase in fat acidity, as this parameter increased after 45 days in metal cans where as in the stored grain in plastic jars and plastic gunny the increase was observed only after 60 days. Irradiation and insecticide treatments could equally control the bacterial count (cfu) up to 30 days only after which increase in bacterial count was observed irrespective of the storage containers used. Uric acid content significantly increased after 90 days from 4.2 to 7.62, 8.24 and 7.76 g/100g grain in plastic gunny and metal can respectively which could be the result of insect infestation observed in the grain. The increase was lower in all the treated grain samples stored in different types of containers compared to control. However even after 80 days of storage the uric acid level was within the permissible limits (10mg.100g). The storage studies conducted on open market sample indicated that application of bio insecticide (spinosad), herbal insecticide (parad) was as effective as malathion which is used for treating grains for seed purpose whereas irradiation was less effective at the level of application tested i.e 0.25kGy and0.5kGy. Storage stability was found to be almost doubled by these treatments except irradiation. Weight loss was minimum in spinosad (0.62%) followed by Parad (1%), malathion (2%), irradiation (15%) as compared with 21.5% in control. The uric acid content could be controlled within permissible limits due to application of treatments. This study suggests that application of bio insecticide (spinosad) is effective for grain protection during storage particularly at house hold level, but on account of the cost it may not be suitable for bulk storage. As an alternative herbal insecticide (parad) is equally effective as a treatment for pearl millet during storage.

Effect of irradiation on the shelf life of grain and flour

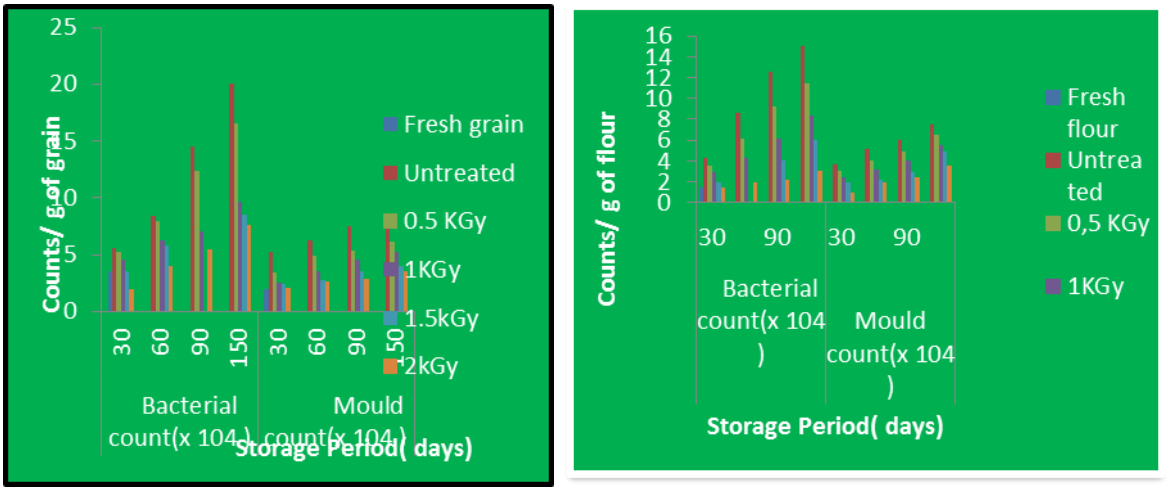
Since the irradiation level up to the dosage of 0.5 KGy could not effectively increase the shelf life of the grain in the earlier experiment, another study was taken up in which the grain as well as flour samples were irradiated at higher levels i.e 0.5. 1.0. 1.5 and 2.0 KGy . The grain and flour was packed in HDPE bags of 1 Kg capacity and irradiated at the various levels and kept intact up to 150 days. Peroxide value and bacterial and mould load was determined at regular intervals of 30, 60, 90, 120 and 150 days.



(A) (B)

Fig 5:Effect of irradiation on the peroxide value of pearl millet grain (A) and flour (B)

Irradiation influenced the microbial load of the grain as well as flour. With increasing dose of irradiation from 0.5 to 2 kGy the number of bacterial and mould colonies were reduced proportionately (fig 6).



(A) **(B)**

Fig 6: Effect of irradiation on the microbial counts of pearl millet grain (A) and flour (B)

The results of this study indicated that application of gamma radiation at 2kGy though results in an increase in the peroxide value, it is still able to control the microbial growth as assessed by the lower bacterial and mould counts. However, the increased peroxide value (PV) did not affect the overall quality of the grain as well as flour, hence irradiation can be recommended for increasing the shelf life of grain and flour. Dosage of 2 kGy is desirable to balance between the negative effect of increased PV and the positive effect of decreased microbial counts. Since irradiation is cost effective and has other benefits on grain and flour stability during storage, this treatment could be recommended for bulk storage of pearl millet.

Development of pearl millet based Multigrain flour

Multi grain product was prepared using malted and unmalted pearl millet and other grains in varying combinations. Malting improves nutritional quality and bioavailability of several nutrients. However, this treatment will also result in breakdown of starch to simple sugar which is not desirable for people who have hyperglycemia. Hence multigrain product using unmalted grain was also designed to meet the requirement of above segment of the population. In addition to this, the other grains were selected to enhance the soluble fibre content such as barley and protein and antioxidant content by addition of soybean flour. The nutritive value of multi grain flour is given in Table 10. Several food items were tried out using the multi grain flour.

Formulation of multigrain flour

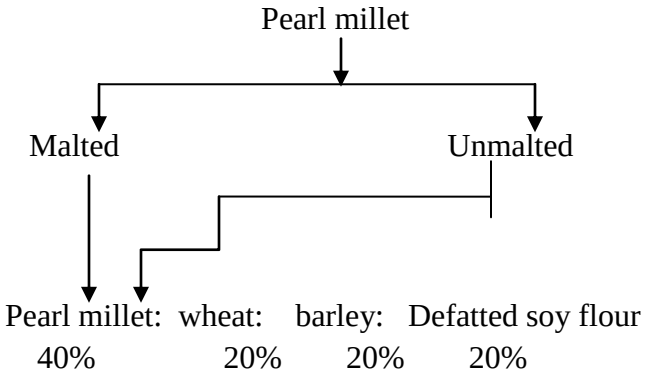


Table 10: Nutritive value of peal millet based multigrain flour

Nutrient /100g	Pearl millet flour (Dehulled)	Multigrain flour*
Energy (g)	361.0	365
Carbohydrates (g)	67.5	59
Protein (g)	10.9	18
Fat (g)	2.8	2.6
Fibre (g)	0.8	2.3
Calcium (mg)	42.0	80
Phosphorus (mg)	236	370
Iron (mg)	3.50	6.5

**** Unmalted***

Sensory evaluation: Sensory evaluation was done for appearance, colour , flavor, taste and over all acceptability. The scores for overall acceptability of the products are given in table 11. The mean scores indicated that all the products were accepted well on par with the respective control products prepared traditionally using wheat or rice.

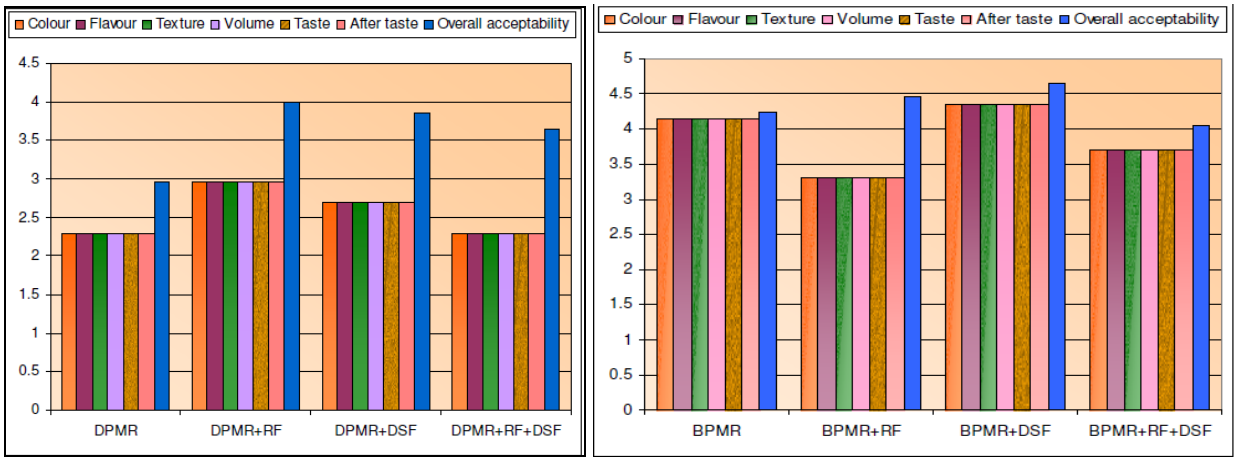
Table 11: Overall acceptability of recipes prepared from pearl millet based multigrain flour in comparison to control

SNo	Product	Control	Multigrain (malted)	Multigraim (unmalted)
1.	Dosa	4.1	4.1	3.8
2.	Utappam	4.2	4.1	3.8
3	Roti	4.5	4.2	4.0
4	Porridge	4.0	4.1	3.8

Extruded products

Ready to eat (RTE) snacks

Formulations based on dehulled fine pearl millet semolina in combination with rice flour, soya flour in different proportions were tried out for development of ready to eat salt and sweet snacks. The best formulation was identified through sensory evaluation by a panel of 10 trained judges using 10 point hedonic scale/ The mean sensory scores for overall acceptability are shown in fig.7 .



DPMR: Dehulled Pearl Millet BPMR: Blanched Pearl Millet Rawa ;RF: Rice flour ; DSF: defatted soya flour

Fig 7: Overall acceptability of pearl millet based extruded snacks

Acceptability study

Based on evaluation by the sensory panel and rated as best, the products were subjected to acceptability study carried out at Krishi High School, Rajendranagar, Hyderabad. Students (100) of VII to X class who come under 12-15 years of age were given sweet and salt RTE snacks and sensory attributes such as colour, appearance, texture, taste, after taste, overall acceptability were studied. Among the two products i.e. sweet and salty given to children, the salty sample ranked better than the sweet one.

Shelf-life extension of sorghum based roti

Two types of formulations were used for the development of sorghum roti. In the first formulation, whole sorghum flour, wheat flour and defatted soy flour, hydrocolloids, oil, maltodextrins, yeast, mould inhibitor, acid regulators were used to prepare sorghum based roti and its shelf life was evaluated for a period 7 days.

Table 12: Formulations used for sorghum based roti

Formulation	Ingredients (%)									
	Whole sorghum flour	Wheat flour	Defatted soy flour	Mould inhibitor	Acid regulator	Malto dextrin	Hydro colloid	Oil	Yeast	GMS
WS(control)	60	30	10	--	--	--	--	--	--	--
WSM	60	30	10	0.3	0.2	0.3		--	--	--
WSG	60	30	10	0.3	0.2	--	0.3	--	--	--
WSG-A	60	30	10	0.3	0.2	--	1	--	--	--
WSG-B	60	30	10	0.3	0.2	--	1	1	--	--
WSG-C	60	30	10	0.3	0.2	--	1	1	1	1

***WS**: Whole sorghum flour, wheat flour and defatted soy flour; **WSM**: Whole sorghum flour, wheat flour, defatted soy flour, CP, FA, Maltodextrin; **WSG:** Whole sorghum flour, wheat flour, defatted soy flour CP, FA SG3, **WSG-A**:Whole sorghum flour, wheat flour, defatted soy flour, CP, FA, SG3; **WSG-B:** Whole sorghum flour, wheat flour, defatted soy flour, CP, FA, SG3, oil; **WSG-C:** Whole sorghum flour, wheat flour, defatted soy flour, CP, FA, SG3 oil, yeast, GMS*

The roti quality was evaluated in comparison with the control (WS). The thickness of the roti was more in the formulations WSG, WSG-A, WSG-B where hydrocolloid was incorporated and the spreading was more in WSG-B as in addition to hydrocolloid oil was added in this formulation. Except control, the shelf-life of all the rotis could increase for seven days without any mould growth much change in texture. The combination (WSM) where maltodextrin was used the roti texture was good up to 4 days later the roti became brittle and it was very hard to chew. Hence the combination was modified with the addition of hydrocolloid and oil. Sensory scores showed that among the formulations WSG-B formulation was scored high in terms of texture, taste and overall acceptability.

Table 13: Mean scores of the sensory evaluation (7th day storage) of the sorghum based multigrain roti

Attributes	Formulations					
	WS	WSM	WSG	WSG-A	WSG-B	WSG-C
Colour	3.9	3.2	3.7	4.2	4.4	3.4
Flavour	3.8	3.2	3.7	4.2	4.2	3.3
Texture	2.7	2.8	2.8	3.4	3.6	3.4
Taste	3.4	3.1	3.2	3.6	3.9	3.2
After taste	2.9	3.0	3.2	3.4	3.7	3.4
Overall acceptability	3.2	3.2	3.5	3.6	3.8	3.2

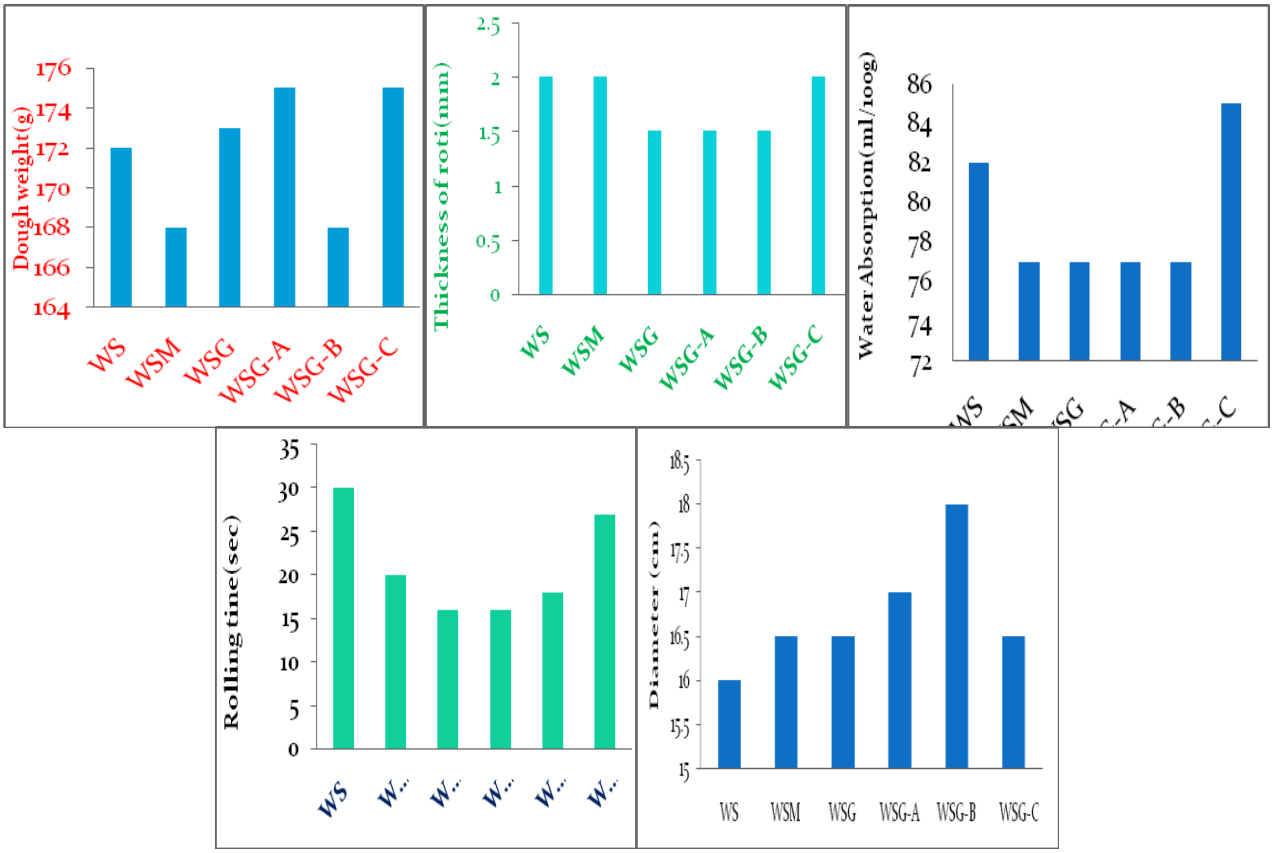


Fig 8: Water absorption, rolling time and diameter of different formulations used for sorghum based multigrain roti

***WSH**: Whole sorghum flour, wheat flour, ragi flour, urad dal flour defatted soy flour; **WSU-1**: Whole sorghum flour, wheat flour, ragi flour, uraddal flour, defatted soy flour , CP, FA, SG3 oil, SSL, Enzyme(0.5%); **WSU-2**: Whole sorghum flour, wheat flour, ragi flour, uraddal flour, defatted soy flour , CP, FA, SG3 oil, SSL, Enzyme(1%); **WSB-1**: Whole sorghum flour, wheat flour, ragi flour, uraddal flour, CP, FA, SG3 oil, SSL, Enzyme(0.005%); **WSB-2**: Whole sorghum flour, wheat flour, ragi flour, defatted soy flour ,barley CP, FA, SG3 oil, SSL, Enzyme(0.005%); **WSB-3**: Whole sorghum flour, wheat flour, ragi flour, defatted soy flour barley flour CP, FA, SG3 oil, SSL, Enzyme(0.005%);*

2.1.3 Shelf-life extension of sorghum incorporated roti

In the second formulation, whole sorghum flour, wheat flour, ragi flour, blackgram dhal, barley flour, defatted soy flour, hydrocolloids, oil, maltodextrins, SSL, mould inhibitor and acid regulators were used to prepare sorghum based roti and its shelf life was evaluated for a period 7 days. Among 5 formulations tested, WSB-3 was better accepted in terms of mould control and maintenance of texture which are the two important critical issues in maintaining the shelf-life of rotis.

Table 14: Different formulations used for sorghum incorporated multigrain roti

Formulations	Ingredients											
	Whole sorghum flour	Wheat flour	Ragi flour	Urad flour	Defatted soy flour	Barley flour	Mould inhibitor	Acid regulator	Hydr colloid	Oil	SSL	Malto genic enzyme
WSH (control)	35	61	2	2	--	--	--	--	--	--	--	--
WSU-1	35	61	2	2	--	--	0.5	0.2	1	1	1	0.5
WSU-2	35	61	2	2	--	--	0.5	0.2	1	1	1	1
WSB-1	35	61	2	2	--	--	0.5	0.2	1	1	1	0.005
WSB-2	30	50	5	--	10	5	0.5	0.2	1	1	1	0.005
WSB-3	30	40	5	--	20	5	0.5	0.2	1	1	1	0.005

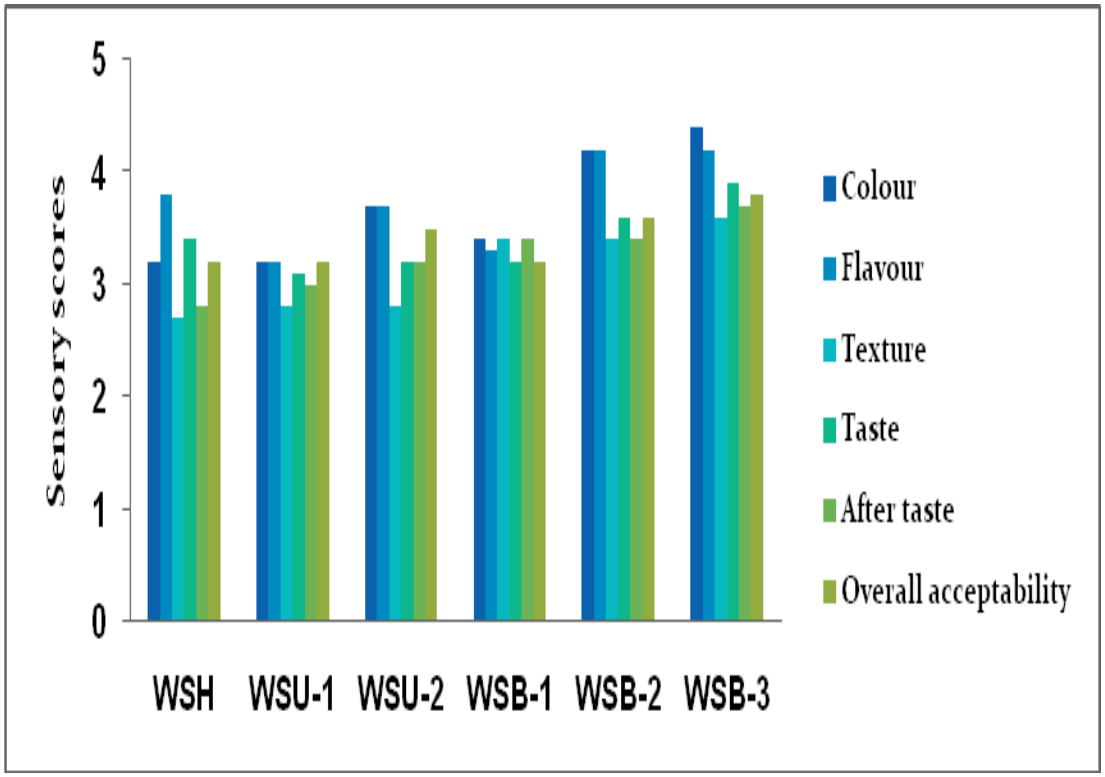


Fig 9: Sensory evaluation of the sorghum incorporated multi grain roti on 7th day

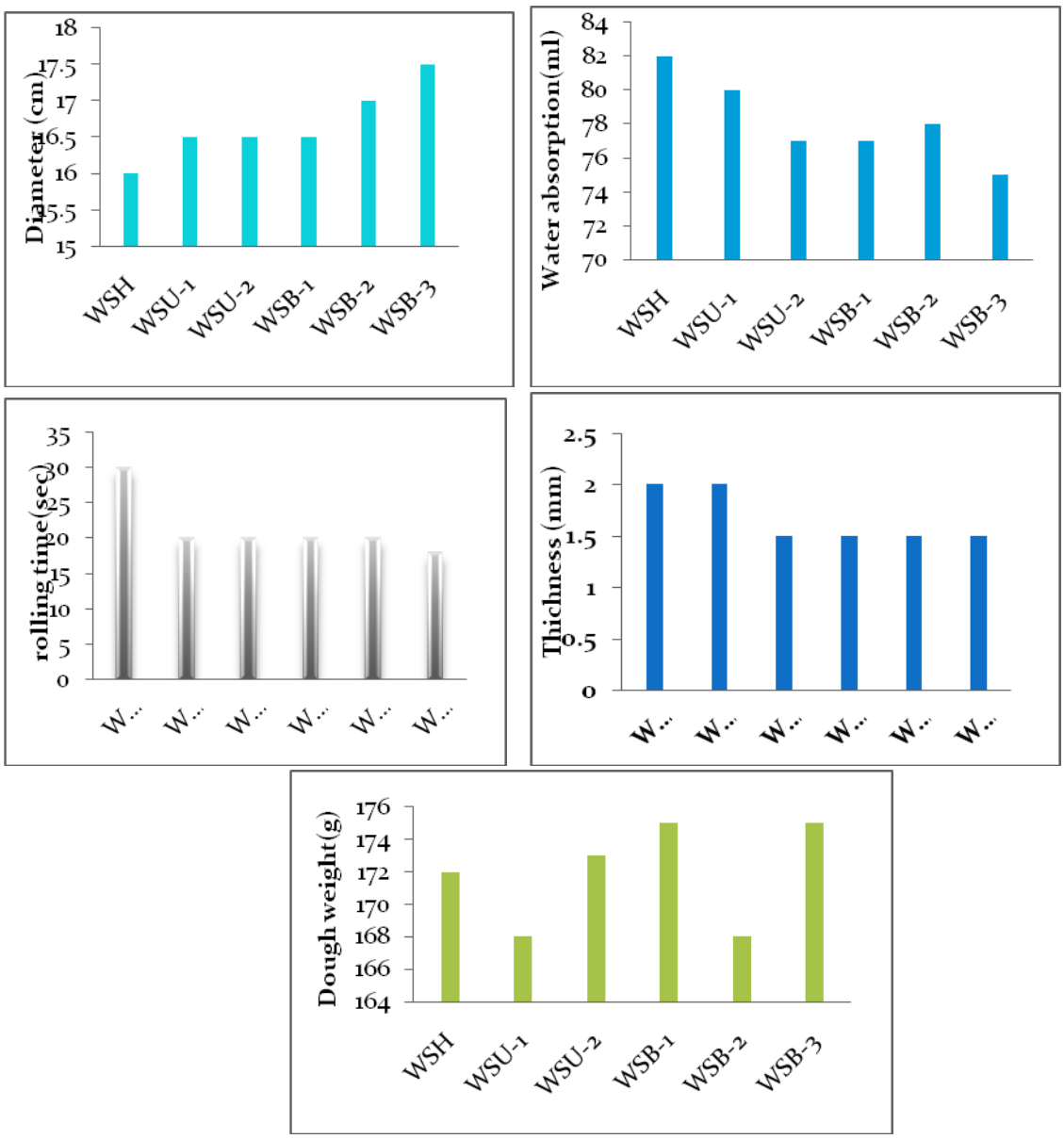


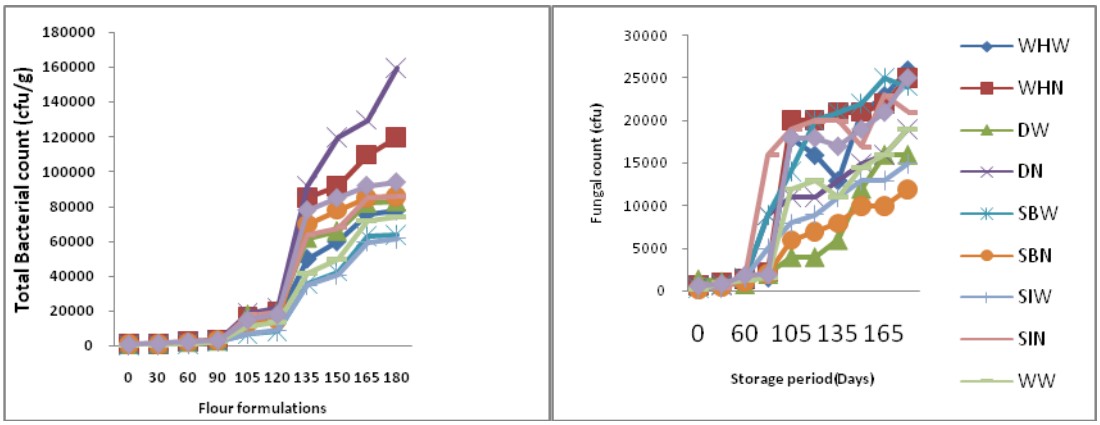
Fig 10: Water absorption, rolling and dough weight of the sorghum incorporated roti formulations

At ANGRAU, sorghum flour (whole and dehulled) as well as multigrain flour was treated with mould inhibitor and acid inhibitor at different percentages and placed in HDPE pouches and kept for shelf life at room temperature. All the samples were tested for moisture, microbial content, free fatty acids, pH, alcoholic acidity periodically up to 6 months.

Table 15: Sorghum flour and multigrain flour formulations with and without flour additives

Sample code	Whole sorghum flour (%)	Dehulled flour (%)	Wheat flour (%)	Defatted soy flour (%)	Ragi flour (%)	Barley flour (%)	Mould inhibitor (%)	Acid regulator (%)
WHW1	100	--	--	--	--	--	0.5	0.2
WHN1	100	--	--	--	--	--	--	--
DW1	--	100	--	--	--	--	0.5	0.2
DN1	--	100	--	--	--	--	--	--
SBW1	60	--	30	10	--	--	0.5	0.2
SBN1	60	--	30	10	--	--	--	--
SIW1	30	--	40	20	5	5	0.5	0.2
SIN1	30	--	40	20	5	5	--	--
WW1	--	--	100	--	--	--	0.5	0.2
WN1	--	--	100	--	--	--	--	--

The microbial growth both bacterial and fungal was monitored during storage and it was found that up to four months the counts were in permissible limits. Beyond 4 months the growth crossed the limit (50,000 cfu) and more counts were seen in the flours without additives. However least microbial growth was seen in the SIN formulation indicating sorghum incorporated flour with additives are more resistant than those of other formulations. The changes in the bacterial and fungal count during storage were shown in fig 11. The moisture content of the flour was within the permissible limits (14%) and ranged from 9.6 to 11.5. Flour formulations without the additives exhibited lower moisture changes during storage. FFA and alcohol acidity of flour was within the permissible limit for a period of 4 months. Lowest FFA was observed in SIW formulation while highest in WN and similar trend was seen in case of alcoholic acidity SIW flour (Fig.12). Overall the study could demonstrate incorporation of mould inhibitor and acid regulator could arrest significant changes in FFA, alcoholic acidity, and microbial growth which are detrimental to the quality of the flour. Among the studied flour combinations the sorghum flour incorporated formulation (SIW) with 2% acid regulator and mould inhibitor was best maintained the quality characteristics during storage followed by SBW, WHW and DW. However with the improved packaging having higher moisture and oxygen barrier properties it might further enhance the shelf life.



(a) **(b)**

Fig 11: Bacterial (a) and Fungal (b) count in the flour formulations during storage

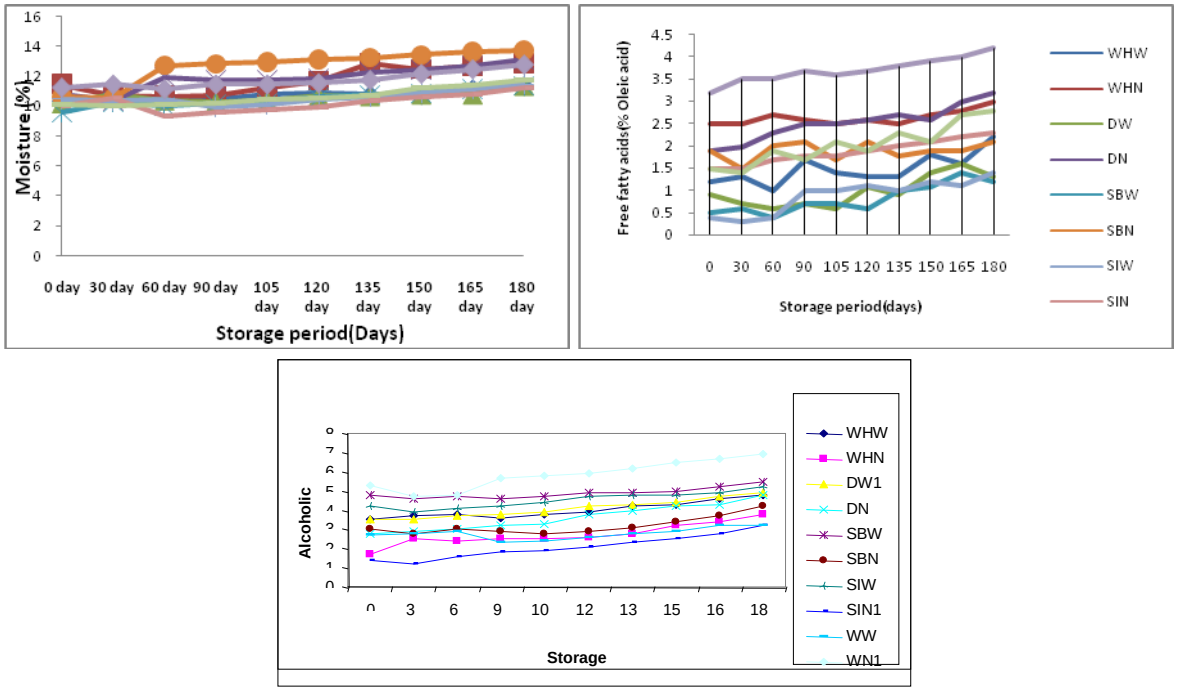


Fig 12: Moisture, free fatty acids and alcohol acidity content of flour during storage

Optimization of technology for commercialization of sorghum based biscuits

Sorghum cookies such as salt, sweet, groundnut, coconut, gluten free salt and sweet biscuits, trans-fat free salt, sweet, groundnut and coconut were prepared at ANGRAU. Sorghum pure salt biscuits were standardized with dehulled sorghum flour (41%), refined wheat flour (16%), skim milk powder (6%), sugar (12%) and fat (25%); sweet biscuits were prepared with dehulled sorghum flour (33), refined wheat flour (13%), skim milk powder (5%), sugar (24%) and fat (25%); coconut biscuits dehulled sorghum flour (29%), refined wheat flour (11%), skim milk powder (4%), sugar (27%), fat (18%) and dessicated coconut (11%); ground nut biscuits were prepared with dehulled sorghum flour (25%), refined wheat flour (10%), skim milk powder (4%), sugar (23%), fat (23%) and ground nut (15%).

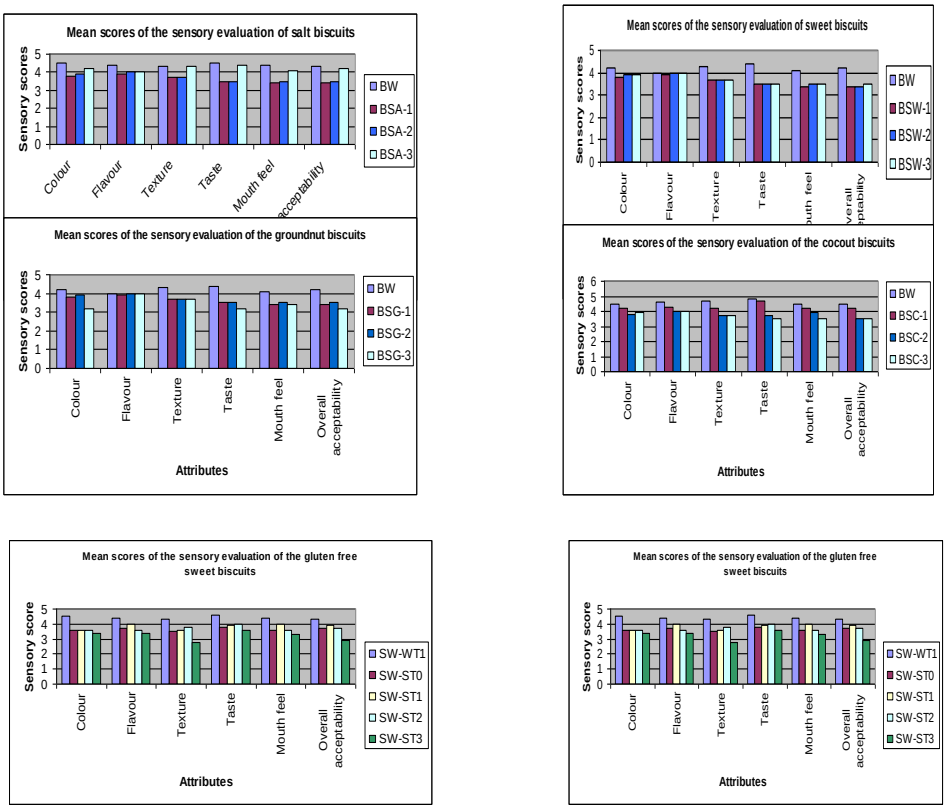


Fig 13: Mean scores of Sensory evaluation of different sorghum biscuits

Standardized gluten free sweet biscuits were with dehulled sorghum flour (43%), sugar (27%), fat (27%) and calcium casienates (3%); salt biscuits with dehulled sorghum flour (26%), pearl millet flour (26%) sugar (13.3%), fat (27%), salt (2.7%) and calcium casienates (5%).

Table 16: Nutrient composition of sorghum biscuits

Nutrients	Sweet	Salt	Coconut	Groundnut
Moisture (g)	6.64	16.8	9.23	4.7
Protein (g)	14	9.1	8.73	9.13
Fat (g)	27.7	27	27	29
Energy (kcal)	468	499	484	524
Dietary fibre (g)	20.0	23.0	23.6	25.3
Calcium (mg)	92.1	162.8	121.4	85.4
Iron (mg)	0.68	1.8	0.8	0.8
Zinc (mg)	0.41	0.91	0.82	0.6
CHO	40.7	55.1	51.6	56.6
Magnesium	62.0	78.0	55.3	50.3
Ash	22.386	16.082	24.412	23.73
FFA	0.225	0.282	0.282	0.282

Trans fat free sweet biscuits were standardized with dehulled sorghum flour (33%), refined wheat flour (12.5%), skim milk powder (5%), sugar (25.2%) and fat (23.3%); trans fat free salt biscuits with dehulled sorghum flour (41.2%), refined wheat flour (16%), skim milk powder (6.4%), sugar (12.1%) and fat (21.9%); trans fat free peanut biscuits with dehulled sorghum flour (25%), refined wheat flour (10%), skim milk powder (4%), sugar (23%),fat (20%) and peanuts (15%); transfat free coconut biscuits with dehulled sorghum flour (29%), refined wheat flour (11.1%), skim milk powder (4.6%), sugar (26.5%), fat (15.5%) and coconut (11.1%).

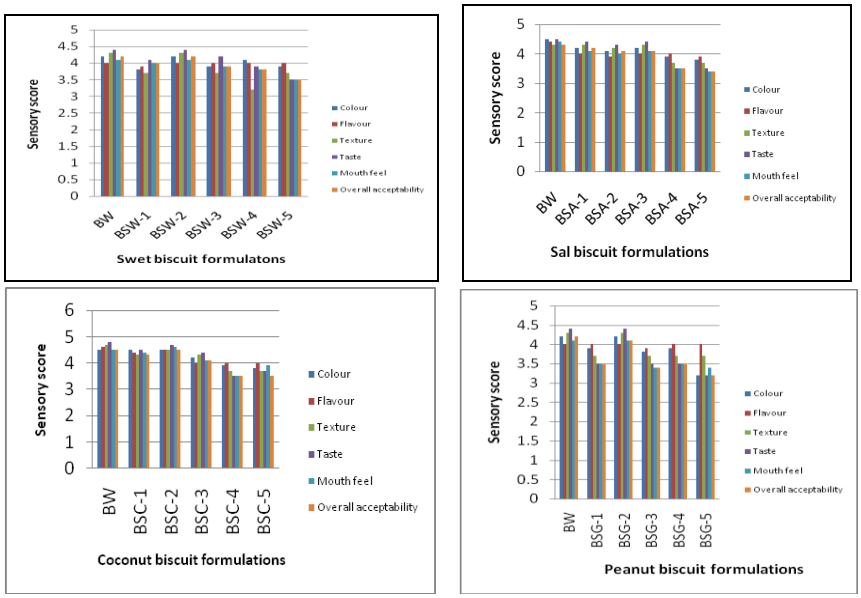


Fig 14: Mean scores of Sensory evaluation of different trans fat free sorghum biscuits

Since there is growing demand for low calorie biscuits, an attempt was made to develop and standardize four kinds of sorghum biscuits by replacing the cane sugar with low calorie sweetener which gives 50% of the kcal from regular sugar. Low calorie salt biscuits were prepared with dehulled sorghum flour (41.2%), refined wheat flour (16%), skim milk powder (6.4%), low calorie sugar (12.1%), and fat (24.3%); sweet biscuits were prepared with dehulled sorghum flour (33%), refined wheat flour (12.5%), skim milk powder (5%), low calorie sugar (25.2%), and fat (24.3%); low calorie coconut biscuits were with dehulled sorghum flour (28.8%), refined wheat flour (11.1%), skim milk powder (4.4%), low calorie sugar (26.6%), and fat (17.7%) and coconut (11.1%); low calorie groundnut biscuits were with dehulled sorghum flour (25%), refined wheat flour (10%), skim milk powder (4%), low calorie sugar (23%), and fat (23%) and groundnut (15.3%).

The standardized formulations were having the highest acceptability than the formulations studied.

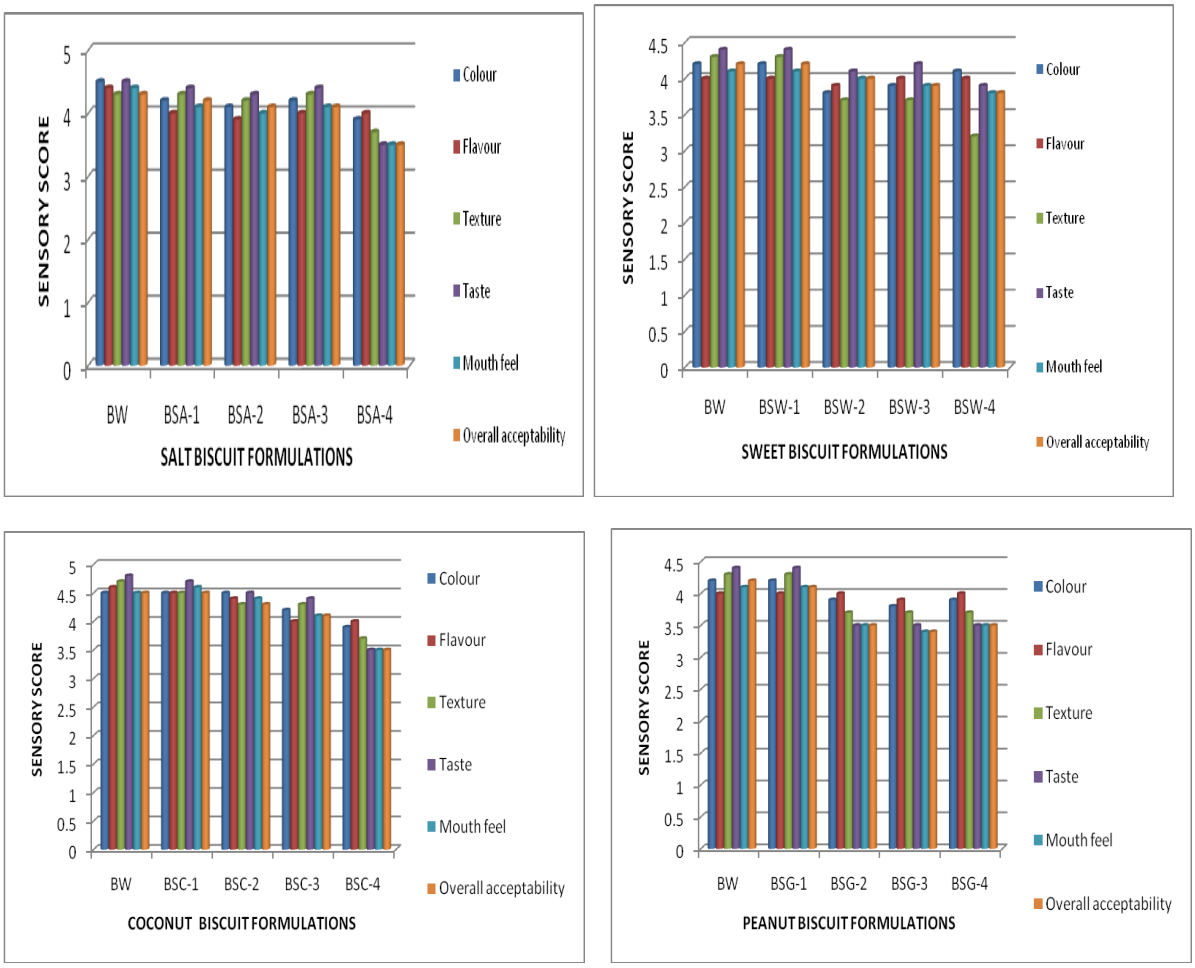


Fig 15: Mean scores of Sensory evaluation of different low calorie sorghum biscuits

Hot extruded snack or ready to eat snack

In food processing, extrusion combines heating with the act of extrusion to create a shaped cooked product. Extrusion is accomplished by single screw and twin-screw extruders. Commercially most of the extruded snacks are prepared from corn; here the extruded snack produced using sorghum grits, rice flour and soya flour. The mixture is combined and passed through twin screw extruder to produce expanded snacks which are ready to eat. The snack can be coated with desired spices to create variations in the taste and flavor. Before arriving into the final formulation several combinations such as sorghum flour ranging from 30 to 70 percent and soy four ranging from 10- 20 percent were tried out to arrive a consistent sensory quality Formulation used in the RTE snack.

Table 17: Composition of raw material for RTE production

Ingredients	Percentage
Dehulled sorghum flour	50
Maize flour	30
Defatted soy flour	15
Roasted Bengal gram flour	5

The grits of all the raw material was conditioned overnight and then extruded in a twin screw extruder at 120°C and extruded with a cutter speed of 350 rpm. The extrudates were then dried in hot air drier and then coated with spice mix and packed in nitrogen flushed pouches.

Table 18: Nutrient composition for sorghum hot extruded snack

Nutrient	Amount
Energy(kcal)	356
Protein (g)	12.9
Fat (g)	4.08
Dietary fibre (g)	12.88
Calcium (mg)	43.5
Iron (mg)	1.73
Zinc (mg)	0.30

Gluten free and fat free sorghum crunches: These are made using whole /dehulled sorghum flour mixing with spice mixes green chilles, Jeera powder, sesame seeds, curry leaves, coriander leaves and salt. All the mixture was conditioned for initiating gelatinization and then the gelatinization was terminated by application of dry heat at high temperature.

Table 19: Nutrient profile of sorghum crunches

Nutrient	Value
Energy(kcal)	343
Protein (g)	10
Fat (g)	1.3
Dietary fibre (g)	21.48
Calcium (mg)	182
Iron (mg)	4.5
Zinc	2.4

Development and optimization of pasta products from pearl millet and sorghum

Formulation of gluten free pasta is usually more exigent than that of gluten containing products, as the major structure forming component, namely gluten is absent. Pasta from millets has a great future since they are rich in fiber and low in fat. In the present study, two sets of formulations were used one incorporating defatted soya flour and other incorporating caseinates.

Table 20: Soy incorporated gluten free sorghum pasta formulation

Formulations	Composition					
	Sorghum semolina	Wheat semolina	Defatted soy flour	Hydrocolloid 1	Hydrocolloid 2	CMC
WS	--	100	--	--	--	--
GP	60	28	10	2	--	--
GP-1	60	28	10	--	2	--
GP-2	60	20	18	--	2	--
GP-3	60	20	18	2	--	--
GFP	60	--	36	2	--	2
GFP-1	71	--	25	2	--	2

The swelling index of wheat pasta was higher than all the millet pasta products. The higher swelling index of pasta products was directly proportional to the water absorption. The pasta containing combination of sorghum and wheat has higher cooking losses when compared to wheat and gluten free sorghum pasta. Cooking losses of pasta are directly related to the higher swelling indices and water .absorption. Cooking time of pasta samples ranged from 12-5minutes

Table 21: Cooking quality of different soya flour incorporated pasta formulation

S.No	Formulation	Swelling index (g of water/g of dry pasta	Dry matter (g/100g of raw pasta)%	Cooking losses (g/100 of raw pasta)	Cooking time (minutes)
1	WS	1.94	90	5.06	14
2	GP	1.118	83	7.95	12
3	GP-1	1.118	80	7.95	12
4	GP-2	0.97	85	7.32	13
5	GP-3	0.97	87	7.32	14
6	GFP	0.64	67	7.08	14
7	GFP-1	0.62	76	6.91	15

WS: *Whole sorghum semolina****; GP:*** *Sorghum semolina, wheat semolina, defatted soy flour, Hydrocolloid1****; GP-1:*** *Sorghum semolina, wheat semolina, defatted soy flour(10%), Hydrocolloid 2****; GP-2:*** *Sorghum semolina, wheat semolina, defatted soy flour (18%), Hydrocolloid2****; GP-3:*** *Sorghum semolina, wheat semolina, defatted soy flour, Hydrocolloid1****; GFP:*** *sorghum semolina, defatted soy flour, Hydrocolloid1****; GFP-1:*** *sorghum semolina, defatted soy flour, Hydrocolloid 1, CMC*

Table 22: Caseinates incorporated gluten free sorghum pasta formulation

Formulations	Composition					
	Wheat Semolina (%)	**Sorghum Semolina (%)**	**Pearl millet Semolina (%)**	**Sorghum &Pearl millet Semolina (%)**	**Calcium Caseinates (%)**	**Hydro Colloids (%)**
WS0	73	-	-	-	-	-
PS0	-	69	-	-	-	-
C-PS1	-	52.5	-	-	8	2
C-PP1	-	-	52.5	-	8	2
C-PC1	-	-	-	52.5	8	2

Table 23: Cooking quality of calcium caseinates incorporated different pasta formulations

S.no	Formulations	Swelling index (g of water/ g of dry pasta)	Dry matter(g / 100g of raw pasta)%	Cooking losses (g / 100g of raw pasta)	Cooking time (minutes)
1.	WS0	2.34	90	5.17	14
2.	PS0	5.41	86	8.46	12
3.	C-PS1	6.296	88	9.06	12
4.	C-PP1	6.174	84	9.120	15
5.	C-PC1	5.814	87	10.46	15

C- PS1*: Sorghum pasta + 8% calcium caseinates;* ***C-PP1****: pearl millet+8% calcium caseinates;* ***C-PC1****: sorghum and pearl millet (50:50) + 8% calcium caseinates;* ***WS0****: wheat pasta;* ***PS0****: Sorghum pasta control*

The swelling index of wheat pasta was lower than all the millet pasta products. Higher swelling indices were recorded for the sorghum pasta (6.296) followed by pearl millet (6.174) and blends of pearl millet and sorghum (5.184). The higher swelling index of pasta products was directly proportional to the water absorption. The pasta containing calcium caseinates has higher cooking losses when compared to wheat. Cooking losses of pasta are directly related to the higher swelling indices and water absorption. Cooking time of pasta samples ranged from 12-15minutes.

Table 24: Mean scores of the sensory evaluation of soya incorporated gluten free pasta formulation

Attributes	Formulations						
	WS	GP	GP-1	GP-2	GP-3	GFP	GFP-1
Colour	4.4	3.7	3.2	3.4	3.9	3.5	4.2
Flavour	3.7	3.2	3..2	3.6	3.7	3.4	3.9
Texture	3.6	2.7	2.8	3.4	3.6	2.8	4.1
Taste	3.6	2.8	3.0	3.3	3.3	2.6	3.8
After taste	4.5	3.6	3.3	4.4	4.4	3.3	4.4
Doneness	3.5	3.0	3.1	3.7	3.9	3.0	4.0
Overall acceptability	3.7	2.9	2.9	3.4	3.7	3.0	4.0

Table 25: Mean scores of the Sensory evaluation of caseinates incorporated gluten free pasta formulations

Attributes	Variations				
	WSO	C-PS1	C-PP1	C-PC1	F ratio
Color	4.7± 0.46	4.1± 0.35	2.8± 0.35	3.3± 0.51	29.76**
Appearance	4.7± 0.46	4.6± 0.51	3.2± 0.46	3.6± 0.51	18.15**
Flavor	4.8± 0.35	4.6± 0.51	2.7± 0.46	3.2± 0.46	41.80**
Texture	5.0± 0	4.3± 0.51	3.0± 0	3.5± 0.53	45.99**
Taste	5.0± 0	4.3± 0.51	3.0± 0	3.5± 0.46	48.65**
After taste, if any	5.0± 0	4.5± 0.53	3.3± 0.51	3.6± 0.51	22.32**
Doneness	4.8± 0.35	4.3± 0.51	3.1± 0.35	3.5± 0.53	25.46**
Overall acceptability	5.0± 0	4.6± 0.51	3.2± 0.46	3.6± 0.51	28.89**

C- PS1*: Sorghum pasta + 8% calcium caseinates;* ***C-PP1****: pearl millet+8% calcium caseinates;* ***C-PC1****: sorghum and pearl millet (50:50) + 8% calciumcaseinates;* ***WS0****: wheat pasta* **Significant at 1% level ****

Among the gluten containing pasta samples the GP-3 combination with wheat semolina 20% and hydrocolloid (1) 2% scored high in terms of colour, taste, and texture. The overall acceptability was similar to control pasta which is 3.7. To develop gluten free pasta hydrocolloids were used to maintain the structure of pasta. Among the standardized variations GFP-1 with defatted soy flour (36%), CMC (2% and SG1 (2%) was scored high. Among the caseinates incorporated gluten free pasta samples C-PS1 with sorghum and caseinates (8%)) was scored high (4.6) followed by C-PC1 (3.6). The results indicated that addition of calcium caseinates improved the sensory properties of pasta products, when compared to control.

Flax seed incorporated sorghum pasta

Flax seed is a rich source of polyunsaturated fatty acids consisting about 80% of total oil with high ratio of omega-3 to omega-6, both of which are essential and eaten as a part of diet since the body does not manufacture them from another source. Flax seed flour was incorporated at different levels in wheat based and sorghum based pasta and the cooking quality was assessed

Table 26: Formulations used for flaxseed incorporated sorghum pasta

Formulation	Wheat semolina (%)	Sorghum semolina (%)	Flax seed flour (%)
WS C	**100**	**0**	**0**
WS +SS C	**60**	**40**	**0**
WS 1	**95**	**0**	**5**
WS 2	**90**	**0**	**10**
WS 3	**85**	**0**	**15**
WS+SS 1	**38**	**57**	**5**
WS+ SS 2	**36**	**54**	**10**
WS+SS3	**34**	**51**	**15**

WS- wheat semolina; WS+SSC- Sorghum semolina control; WS1, WS2, WS3- wheat semolina; 5% ,10%, 15% flaxseed; SS1, SS2:Sorghu semolina at 5%, 10% flaxseed incorporation

Table 27: Cooking quality of flaxseed incorporated sorghum pasta formulations

Formulations	Swelling index (gof water/ g of dry pasta)	Dry matter (g / 100g of raw pasta)%	Cooking losses(g / 100g of raw pasta)	Cooking time(minutes)	Water absorption %
WS C	2.58	89	4.97	12	28
WS +SS C	4.21	86	5.67	13	31
WS 1	3.21	91	6.10	14	34.5
WS 2	2.89	89	7.92	13	39
WS 3	2.71	92	9.67	14	35
WS+SS 1	4.56	89	7.12	13	39
WS+ SS 2	4.42	90	9.45	15	41

Among the variations developed the formulation with the combination of wheat semolina, sorghum semolina at 5 % level of flaxseed incorporation was accepted and it was scored high when compared to wheat pasta. However beyond 5% incorporation sorghum based pasta was not acceptable like wheat pasta indicating the interaction of sorghum grain components with flax did result in the undesirable taste and flavour compounds.

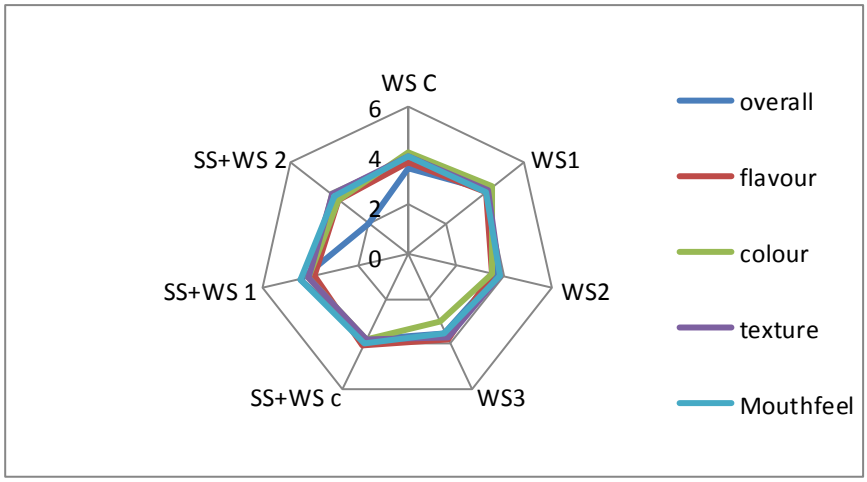


Fig 16: Mean scores of the sensory evaluation of the flaxseed incorporated sorghum pasta

Formulation of designer rawa for enhanced resistant starch

There is considerable interest in the nutritional implications of resistant starch (RS) in foods.

The term "resistant starch" was used to designate mainly enzyme -resistant retrograded amylose but was expanded to all forms of starch that escape digestion and absorption in the small intestines. The positive effect of RS in nutrition is based on the results of the fermentation process during which short chain fatty acids, primarily acetates, propionates and butyrates, are produced. They directly affect the large intestine by decreasing the pH value, which prevents the growth of pathogenic micro-organisms, and increasing the potential for mineral absorption. Fatty acids stimulate colonic blood flow and increase nutrient absorption. Besides physiological benefits in human, RS has been reported to have potential as a unique ingredient that can yield high quality foods. For example, application tests of RS showed improved crispness and expansion in certain pro-ducts and better mouth feel, colour and flavour as compared with products produced with traditional, insoluble fibres. The generation of RS3 after the hydrothermal treatment is due to in-creased interaction between starch components. It has been shown that, after de-branching of starch, the linear chains can contribute to a high RS content. In addition, partial acid hydrolysis and de-branching of amylopectin are very effective in generating RS from various starches. The advantages of de-branching over mild acid hydrolysis include a shorter processing time, better processing control and higher RS yields. The dehulled sorghum was soaked and autoclaved and then incubated with de-branching enzyme and cooling and autoclaving cycles were followed. The de-branching enzyme (2%) is used to enhance the percentage of resistant starch content.

Table 28: Effect of enzyme on the yield of RS content

Treatment	Process Time	Percent increase	RS Content
Control (no treatment)	-	-	12.0
No enzyme	70	27%	16.4
With enzyme	60	54%	24.0

The study demonstrated that the present method improved the yield of resistant starch from 27% to in the earlier method to 54% in the present method. Further the present method reduced freeze-thaw cycles hence the overall cost and time is also reduced compared to the earlier method where in number of freeze –thaw cycles and time are 3 and 3 days as against the 2 and 2 days in the present study respectively.

Directorate of Sorghum Research Processing Interventions

Dehulled sorghum

Sorghum grain is dehulled using a machine called dehuller (*Sowbhagya Industries, Guntur*). Dehulling method is used to separate the outer layer (10%) of the grain, which has less effect on nutritional quality. This processing is necessary to remove mycotoxins on molded grain especially for *kharif* cultivars. Fine flour produced from dehulled grain is used for the preparation of bakery foods, snack foods and instant mixes that resembles rice and wheat products in quality. The unit dehulls 10-15 kg grain per batch in 20 minutes. The recovery of dehulled sorghum is 90%.

Development of sorghum products

Flour, coarse, medium and fine semolina were prepared from the grain in a hammer mill (*Centrifugal Compact Pulverizer, Centrifugal Products, Gujarat, India*) through rotating blades which grind the grains in a grinding chamber and pass it through a screen which separates the flour from the larger and ungrounded particles. The recovery of sorghum flour is 85%. Sorghum grain is grinded in a chakki mill (*Sowbhagya Industries, Guntur*) to obtain coarse (1003 µm), medium rawa (500 µm) and fine rawa (250µm) and are separated using a vibration shifter (*Sowbhagya Industries, Guntur*).The recovery of coarse rawa is 20-25%, medium rawa 20-25%, 25% fine rawa and remaining 25% is flour. However, flour and rawa recovery depends on the cultivar and milling process.

Standardization of particle size for different products

Particle size analysis is an important concept to standardize the different grade particles which are used for the preparation of different products. DSR has made an attempt to prepare and standardize sorghum coarse, medium and fine semolina and flour for various recipes preparation. The particle size distribution of processed grain was measured by sifting the grains through the standard BSS test sieves (Jayant make) and compared with the wheat products. The coarse semolina particle size distribution took place in two meshes that are 14 and 16, 22 and 30 for medium semolina, 44 and 60 for fine semolina and 60 and 85 for flour. When compared to control sample, sorghum semolina possess good particle size distribution and can be used for commercialization.

Table 29: Standardization of sorghum different semolina particle sizes in comparison with control sample

S.No	Product	Mesh	Micron size	Passing %	Held %
1	Control Coarse Semolina	12	1405	96.56	3.44
		14	1204	71.73	28.26
		16	1003	53.61	46.38
		22	710	82.44	4.06
2	Control Medium Semolina	16	1003	98.784	1.216
		22	710	73.49	26.51
		30	500	13.063	86.93
		44	355	8.95	91.04
3	Control Fine Semolina	22	710	61.63	38.37
		30	500	45.74	54.25
		44	355	35.86	64.13
		60	250	40.45	59.54
4	Sorghum Coarse Semolina	12	1405	99.11	0.88
		14	1204	82.24	17.75
		16	1003	37.94	62.05
		22	710	14.09	85.90
5	Sorghum Medium Semolina	16	1003	98.78	1.21
		22	710	39.97	60.020
		30	500	30.36	69.63
		44	355	22.31	77.68
6	Sorghum Fine Semolina	22	710	99.14	0.85
		30	500	91.33	8.66
		44	355	38.92	61.07
		60	250	57.72	42.27

Effect of parboiling on milling and cooking quality

Parboiling is the process of partial boiling or cooking of grain. Generally grain is soaked until it is saturated, drained and then steamed or otherwise heated to gelatinize the starch. The grain is then dried, dehulled and 'milled' (decorticated). Whole sorghum grain (1 vol.) was suspended in tap water (3 vols, pH 7'0) for 16 hours at room temperature, steamed under 20 kg/cm-2 pressure for 20 minutes, tempered for 30 min to cool, dried at 60^{o}C for 24 hours in a tray drier (*Sandeep Instruments, Delhi*). Par boiled allows sorghum to preserve all the nutritive substances and vitamins.

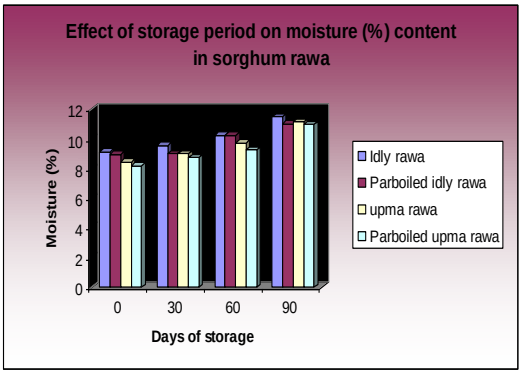
Grains were milled into medium and fine semolina to prepare upma and idly rawa. Physcio-chemical characteristics, shelf life and sensory evaluation of medium and fine semolina were assessed. Parboiling treatment significantly increased the firmness of the cooked kernels, decreased the cooking losses when compared with the control sample (table 30 &31) Moisture content, ash, and alcohol acidity were increased with the storage period in all the samples with the storage period. However, there was a decrease with parboiling than the milling.

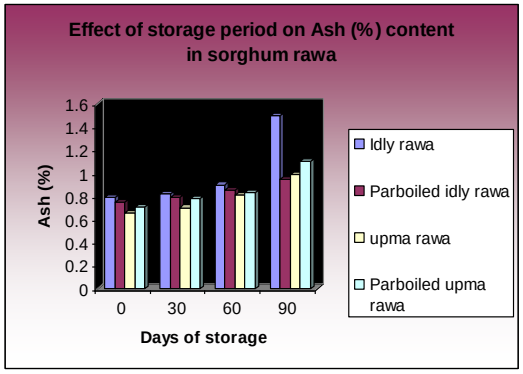
Table 30: Total material loss due to parboiling

Sno	Grain type	Boiling loss	Ruptured Kernels	Bran	Total material loss	Grain yield
1	Control	0.0	0	35	35.0	65
2	Parboiled	1.3	0.2	16	17.5	35

Table 31: Cooking quality of the parboiled grain

S.No	**Grain type**	**Rawa weight**	**Water absorption (ml)**	**Cooking time (min)**	**End product weight (g)**	**Observations**
1	Whole sorghum grain	50	400	25	233	Sticky texture
2	Parboiled sorghum grain	50	400	35	216	Separated grain





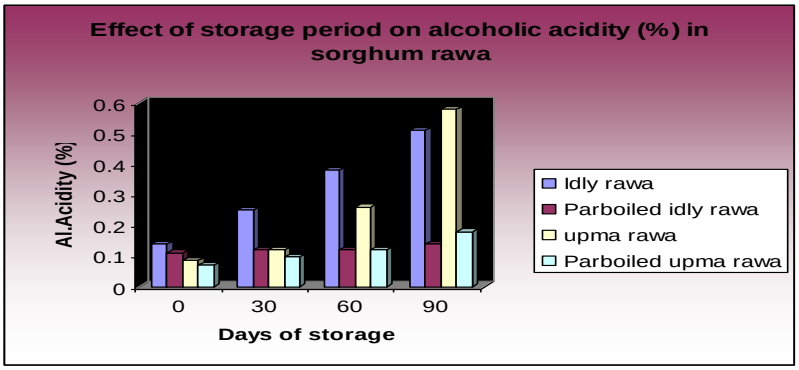


Fig 17: Effect of parboiling on shelf life of products with the storage period

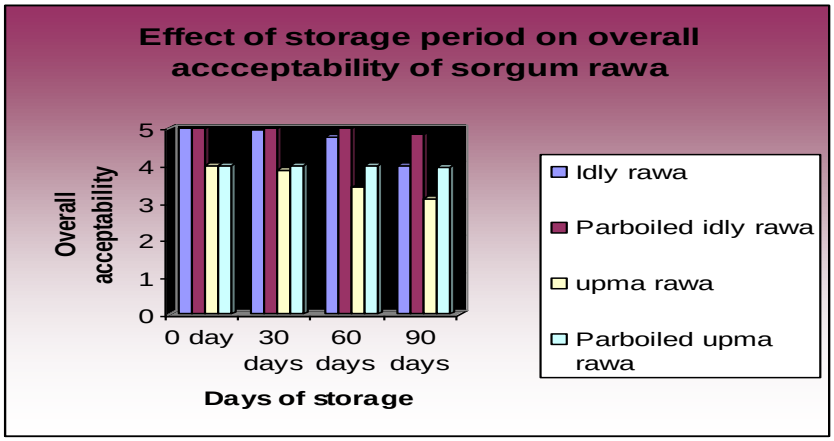


Fig 18: Effect of storage period on Overall acceptability (%) of sorghum rawa

Overall acceptability decreased of all the treatments with the storage period. Acceptability of Parboiled idli rawa and upma rawa scores remaining same up to 3 months compared to normal idli and upma rawa. Hence it can be concluded that parboiling increases the shelf life of the sorghum rawa without any deterioration, it can be stored up to 3 months storage period.

Development and standardization of sorghum rich multigrain flour

Sorghum rich multigrain flour was developed and standardized with sorghum, wheat, ragi, blackgram dhal and fenugreek and shelf life of standardized formulation was assessed through TBHQ (0.02% per 100 g sample).

Table 32: Formulations Used for the Development of Product

Treatment	Ingredients	Rate of Formulations for 100 g Product
T1	S+ W+ R+Bg+Fg	20: 75:1:2:1
T2	S+ W+ R+Bg+Fg	30:65:1:2:1
T3	S+ W+ R+Bg+Fg	40:55:1:2:1
T4	S+ W+ R+Bg+Fg	50:45:1:2:1
T5	S+ W+ R+Bg+Fg	60:35:1:2:1
T6	S	100

(Sorghum +Wheat+ Ragi+ Blackgram dhal+ Fenugreek= S+ W+ R+Bg+Fg)

Among the different blends studied, T4 was found to be having satisfactory functional characteristics such as nutritional composition, bulk density, water absorption and solubility index, and acceptability than other sorghum rich formulations and T4 was studied for shelf life using tertiary butyl hydro quinine (TBHQ; 0.02%/ 100 g sample) on moisture (%), water activity (a_w) and alcoholic acidity and acceptability studies at 0, 30, 60, 90, 105 and 120 days storage period at laboratory level by panel of judges using a 5-point hedonic scale. No significant difference was found between control and TBHQ added samples for moisture content, a_w and alcoholic acidity. Organoleptic properties of T4 blend *roti* (colour, flavor, texture, taste and overall acceptability) were better with addition of TBHQ than the control samples during storage period (fig.19).

Storage studies on sorghum rich multigrain flour in different packages

Effect of storage of sorghum rich multigrain flour (SRMF) packed in low density polyethylene (LDPE), high density polyethylene (HDPE) and polypropylene (PP) under accelerated environment (38^{o}c and 90% RH) on moisture (%), total ash (%), water activity (a_w), alcoholic acidity (%) and bacterial count increased on storage. Among the plastic packages low density and high density gave the least protection, while polypropylene gave the maximum protection against spoilage of SRMF during storage. The bacterial growth was observed on SRMF after 30 days of storage period higher growth was observed stored in LDPE (8x10-1) pack and lower was observed in PP (5x10-1) pack stored multigrain flour, exceed the limit.. Data on the organoleptic qualities showed that the quality of SRMF remained unchanged for 30 days in plastic packages. In LDPE pack started deteriorating after 15 days of storage, as determined by the changes in taste and development of musty flavor.

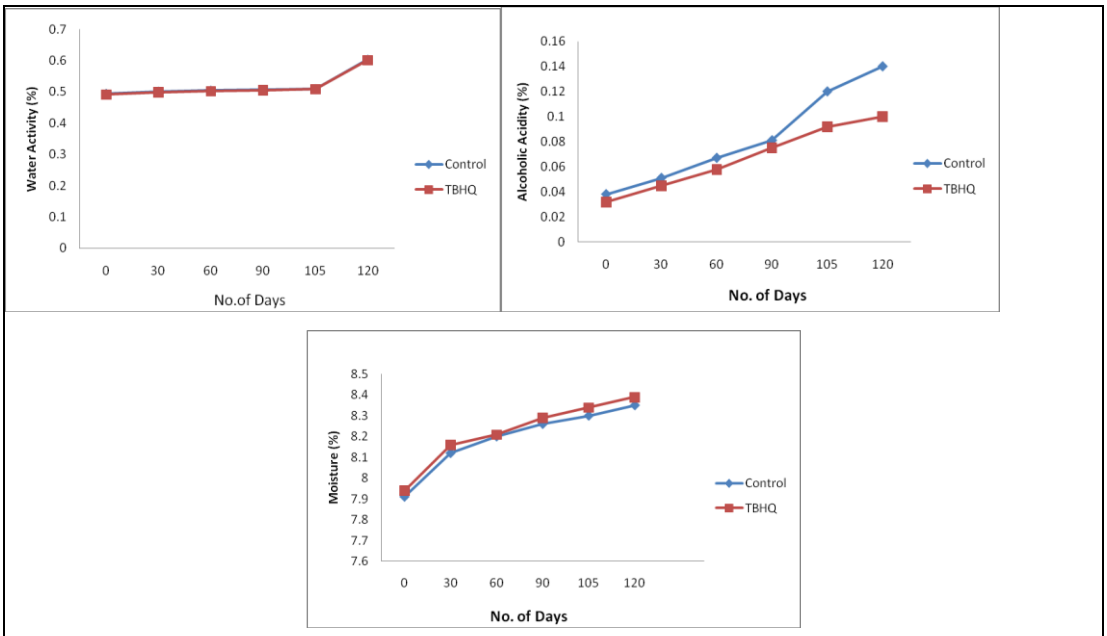


Fig 19: Moisture, water activity and alcohol acidity content of sorghum rich multigrain flour during storage

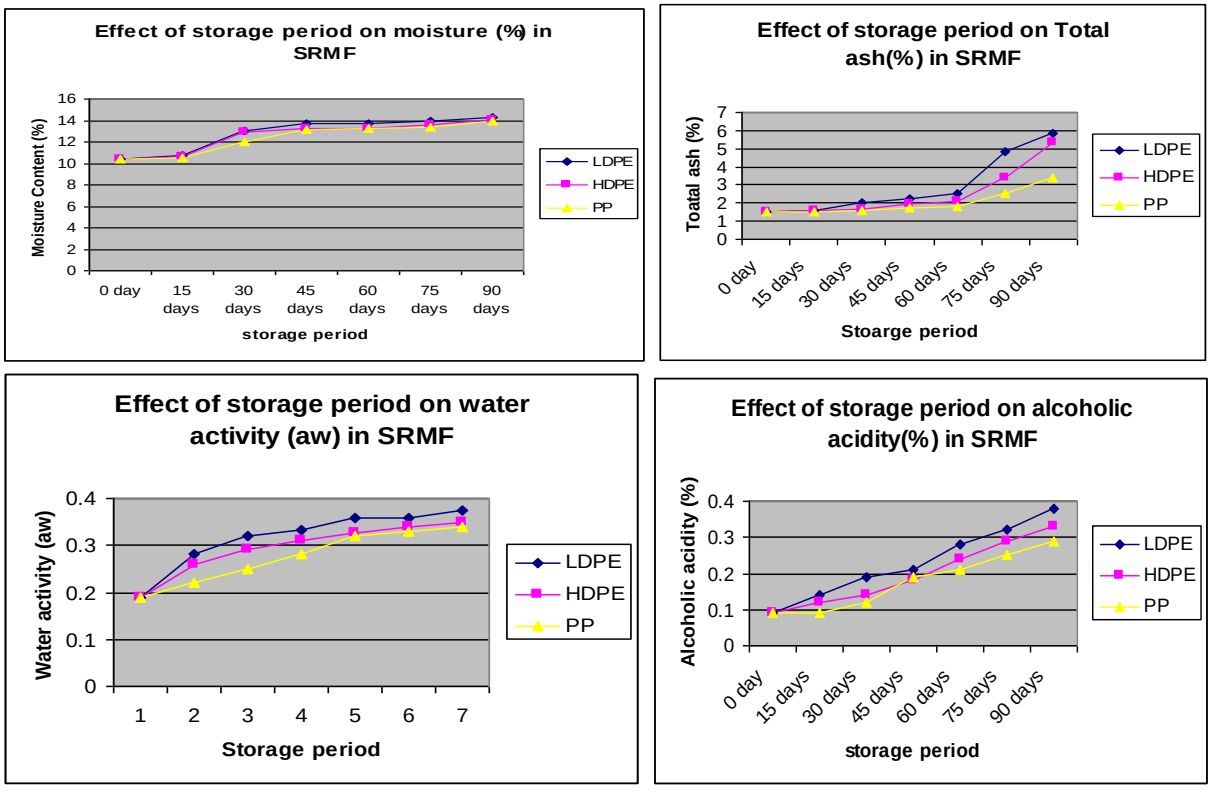


Fig 20: Effect of package on shelf life of sorghum rich multigrain flour with the storage period of 90 days

Effect of milling and particle size of flour on sorghum biscuits

Sorghum (M 35- 1 cultivar) was milled using hammer and chakki mill to obtain flour of different particle size i.e., 75(200 BSS), 106(150 BSS), 150(100 BSS), 180(85 BSS), 250(60 BSS) µm and to prepare biscuits. Biscuits were subjected to physico- chemical analysis using standard methods and its organoleptic properties were evaluated using 9 point hedonic rating scale. Colour, Texture and organoleptic properties showed that biscuits prepared from 250 µm and180 µm size were highly acceptable than the biscuits prepared from other particle size flour and also, biscuits prepared from chakki mill were more acceptable than hammer milled flour biscuits. Sorghum biscuits that are highly acceptable can be prepared from 250µm to 180 µm particle size flour from chakki mill (fig.21).

Table 33: Physical characteristics of sorghum biscuits

Particle Size (µm)/ Mesh Size	Thickness# (mm)	Weight# (gm)	Texture## (Kg/sec)	Colour ##		
				L*	a*	b*
Chakki Mill						
60	1.087	1.182	5.35± 1.02	68.89±0.01	6.41±0.04	29.7±0.03
85	1.128	1.182	5.46± 0.39	70.54±0.006	5.15±0.01	27.25±0.02
100	1.392	1.198	4.76± 1.31	57.79±0.006	10.83±0.03	30.33±0.02
150	0.985	1.251	3.09± 1.29	64.46±0.01	9.35±0.03	31.49±0.03
200	1.269	1.22	2.95± 0.09	69.83±0	7±0	29.99±0.02
Hammer Mill						
60	1.186	1.214	5.41± 0.93	57.79±0.02	10.56±0.005	30.66±0.07
85	1.06	1.218	3.81± 0.19	52.69±0.005	13.77±0.01	32.85±0.11
100	1.06	1.257	3.8± 1.07	58.13±0.01	10.79±0.02	10.79±0.09
150	1.035	1.31	2.66± 0.25	54.96±0.02	12.2±0.04	32.58±0.03
200	1.053	1.269	4.08± 1.07	57.45±0.02	10.90±0.02	25.40±0.1

Dough & Biscuits; ## Biscuits

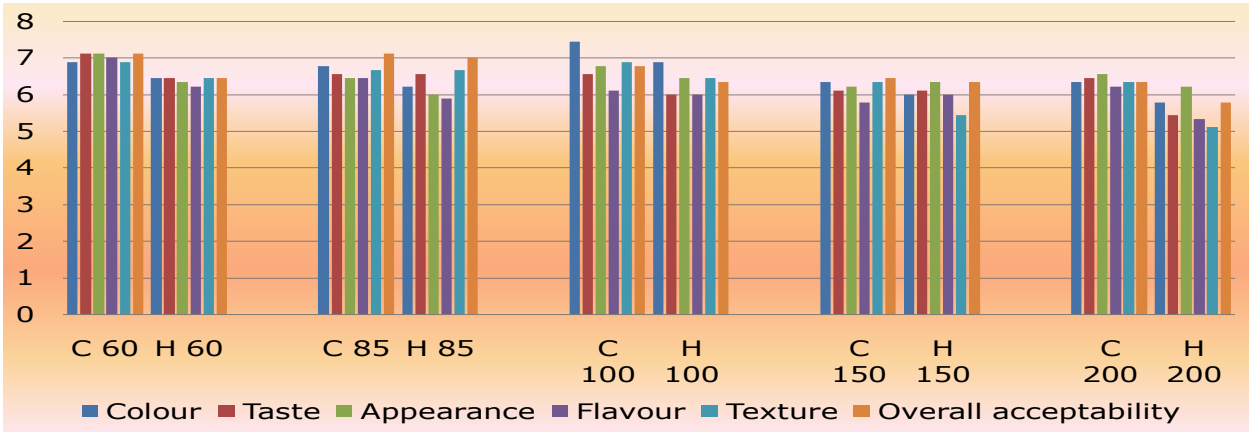


Fig 21: Sensory evaluation of sorghum biscuits prepared from different particle size of flour

Development of sorghum cookies

In order to optimize the proportions used in the biscuit production different proportions were used to maximize the acceptability for commercialization in large scale. At DSR pure sorghum, transfat free and choco- biscuits were standardized. Pure sorghum cookies were prepared with fat (16.5%), sugar powder (9%) water (24%), skimmed milk powder (3%), sorghum flour (45.0%), salt (0.4%), baking powder (0. 6%) and essence (1.5%), whereas chocolate cookies were prepared with sorghum flour (31%), wheat (24%), sugar (15%), fat (12%), skim milk powder (1.6%), cocoa powder (1.6%), chocolate chips (10%), flavor (3.3%), salt (0.3%) and baking powder (1.2%). Trans fat free biscuits were prepared with trans free fat (16.5%), sugar powder (9%) water (24%), skimmed milk powder (3%), sorghum flour (45.0%), salt (0.4%), baking powder (0. 6%) and essence (1.5%)

Development and standardization of sorghum flakes

Flaking of grain is a traditional process which has been known to man since times immemorial. Earlier paddy was hydrothermally treated and this paddy was beaten using a pestle and mortar. In the mechanization of this process an Edge-runner is used it has been developed by Directorate of sorghum Research (DSR), ICAR where roasting of the soaked jowar is carried out in roaster, where the starch will get gelatinized, which was modified for the purpose. The roasted jowar was dehusked, polished and then flattened to desire thickness in edge runner. The flaking process was presented in fig.22.

In the mechanization of this process an Edge-runner is used. This machine consists of rotating steel drum with perforated sieve at the bottom. At the edge (near the rim) an idle roller is present whose gap from the rotating drum is varied depending on the need. Processed and conditioned jowar is fed to this machine and jowar is made to pass between the gap of the roller and rotating drum thus pressing the jowar repeatedly owing to this the grains are flaked and in the process husk and a little amount of bran are removed. Since the husk and bran are smaller in size than that of the flakes, falls off through the sieve and is collected separately. Jowar flakes were dried under sun drying for 3 hrs. The jowar flaking technology parameters i.e. soaking time, roasting temperature, roasting time, incubation time & flaking time were standardized and optimized.

The Flaking technology from edge runner were standardized and optimized the parameters viz soaking time, roasting temperature, roasting time, incubation time and flaking time were standardized by comparing with recovery yield. The optimized conditions are given below

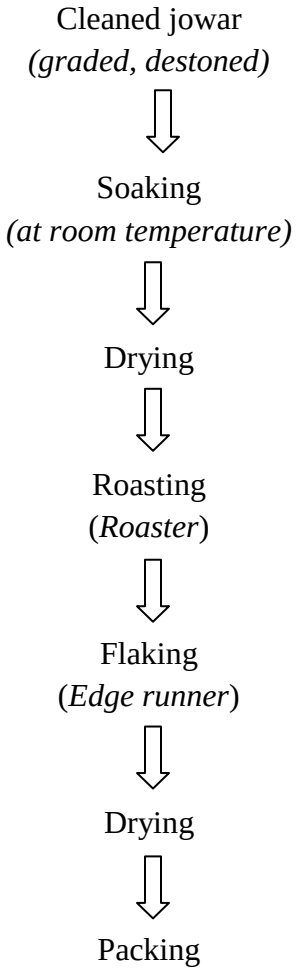


Fig 22: Flow chart for the preparation of sorghum flakes

Jowar (thin) flakes optimized parameters

Soaking time	16hrs
Roasting Temperature	310^{o}C
Roasting time	90 Sec
Incubation time	20 Sec
Flaking time	210 Sec
Sample weight for replication	500 g

The nutritional composition of sorghum flakes was presented in Table 34. Sorghum flakes are rich in nutrients viz protein (7.23g), dietary fiber (5.97g), Calcium (10.94mg), iron (8.77mg) and magnesium (68.9mg)

Table 34: Chemical properties of Sorghum flakes

Nutrients (100g)	Amount
Moisture (g)	10.55
Protein (g)	7.23
Fat (g)	1.79
Total Dietary Fibre(g)	5.97
Insoluble (g)	5.43
Soluble (g)	0.54
Carbohydrates (g)	73.8
Calcium (mg)	10.94
Magnesium (mg)	68.9
Copper (mg)	0.1
Manganese (mg)	0.53
Iron (mg)	8.77
Zinc (mg)	0.88
Phosphorus (mg)	110
Thiamine (mg)	0.45
Niacin (mg)	1.93
Riboflavin (mg)	0.15
Tot. Carotenoids (mg)	ND
B-Carotene (mg)	ND
Tot Folic Acid (µg)	1569
Vitamin C (mg)	ND

Amino acid (g/100g of protein)	Sorghum Flakes
Aspartic	6.32
Threonine	3.17
Serine	4.86
Glutamicacid	24.8
Proline	3.64
Glycine	2.89
Alanine	11.36
Cysteine	0.48
Valine	5.44
Methionine	0.60
Isoleucine	3.88
Leucine	14.6
Tryosine	4.00
Phenylanine	5.64
Histidine	2.22
Lysine	2.03
Arginine	3.68

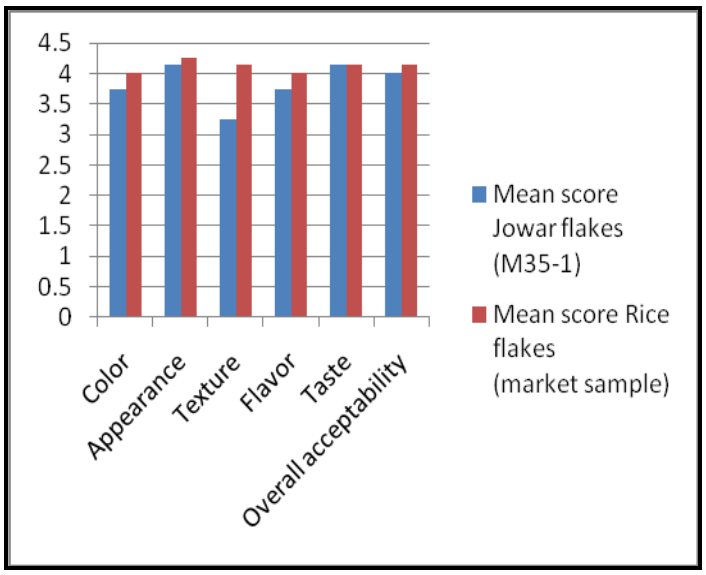


Fig 23: Sensory evaluation of sorghum flakes

Development and standardization of sorghum pasta

Sorghum pasta was developed using sorghum and wheat as main ingredients. The formulations used were given in table 35.

Table 35: Formulations used for preparation of sorghum pasta

S.No	Treatment	Ingredients	Formulation (%)
1	T1	S+W	50:50
2	T2	S+W	60:40
3	T3	S+W	70:30
4	T4	S+W	80:20
5	T5	S	100

(Sorghum Semolina, Wheat Semolina: S+W)

Table 36: Nutrient Composition of Pasta

Treatment	Moisture (%)	Protein (g)	Fat (g)	Fiber (mg)	Amylase (%)	CHO (g)	Energy (kcal)
T1	8.25	9.7	0.44	0.90	13.78	74.2	348.4
T2	8.32	9.5	0.73	0.76	13.98	72.5	348.1
T3	9.20	9.3	0.70	0.77	15.33	71.5	347.8
T4	9.41	9.0	0.82	0.77	16.59	71.3	347.5
T5	10.02	9.6	0.84	1.02	18.48	74.7	349.0

The moisture level was higher in (T5), followed by T4, T3, T2, and T1 extrudates. However, the optimum moisture level was seen (<14%) in all the extrudates. The protein content was higher in T1, followed by T2, T3, T4 which could be due to addition of wheat. The fat and fibre content was higher in T4 and T5 extrudates than the other formulated extrudates. The amylose content was higher in control sample (T5) and among the experimental samples it was higher in T4 followed by T3, T2 and T1. The amylose content was gradually decreased (T5-T1) with an increase in wheat composition. The amylose content of sorghum is higher than wheat that might have contributed higher amylose content in higher sorghum concentrations. The energy value of all products was similar ranging from 348 to 349 Kcal. The millet and cereal based extrudates meets the nutritional requirements indiscriminate of age i.e. providing 300 Kcal and nearly 10 g protein/100 g.

Table 37: Quality characteristics of Sorghum Pasta

Treatment	Cooking time min)	Cooked wt. (g/100g)	Water absorbed (g/100g)	Solid loss (g/100g)	WSI	WAI
T1	6.0±0.53	17.75±0.20	180.48±5.12	7.41±0.52	11.28±0.12	21.27±1.56
T2	7.0±0.12	16.25±0.36	199.74±7.15	8.24±0.43	9.43±0.01	31.42±1.24
T3	6.0±0.22	16.75±0.23	177.56±4.40	9.36±0.26	9.32±0.52	31.39±0.27
T4	8.0±0.29	15.75±0.12	120.35±6.22	8.25±0.22	8.50±0.56	38.79±0.03
T5	9.0±0.40	18.25±0.43	86.20±3.50	10.12±0.14	8.38±0.45	36.44±0.08

The cooking time for different samples of sorghum pasta ranged from 6 to 9 min. T5 control sample of pasta showed significantly higher ($p < 0.05$) cooking time of 9 min than other blends (6 min). The percentage water absorbed was in the range of 86.20 to 180.48 g/100 g with sorghum and wheat showing significantly higher percent water absorbed than control sample (sorghum100%) ($p < 0.05$). Cooking loss indicates the ability of the pasta to maintain structural integrity during the cooking process. The solid gruel loss was observed in the range of 7.41 to 10.12 g/100 g and it was the highest for control sample of pasta and lowest for T1 sample, the difference between them being significant statistically ($p < 0.05$). Moreover, with increased cooking time as in sorghum pasta blends, the amylose networks are degraded increasing the cooking losses. In case of blends, the solid loss in gruel was intermediate with T1 sample of pasta showing the lowest percent solid loss with significant difference from other four blends ($p < 0.05$). The water absorption index was found to be more for extruded sample –T5 (36.44±0.08) followed by extruded sample –T4 (38.79±0.03). The water absorption index of the extrudates increased with increase of sorghum semolina in the composite mixes. The water solubility index was more for the extrudates made from composite mix sample – T1 (11.28±0.12) followed by extruded sample –T2 (9.43±0.01), and WSI was less for the extrudates prepared from composite mix sample T5 - (8.38±0.45). The water solubility index of the extrudates increased when wheat semolina incorporation increased from 20% to 50% in the composite mix samples.

Table 38: Sensory Characteristics of the Extrudates

	T1	T2	T3	T4	T5	F value
Color	4.5 ± 0.07	4.4 ± 0.14	4.0 ± 0.07	4.0 ± 0.14	4.4 ± 0.28	21.9**
Flavor	4.4 ± 0.07	4.2 ±0.07	4.1 ± 0.07	4.2 ± 0.14	4.2 ± 0.14	14.8**
Texture	4.3 ± 0.14	4.2 ± 0.07	4.0 ± 0.07	3.8 ± 0.21	3.0 ± 0.35	38.68**
Taste	4.5 ± 0.07	4.4 ± 0.14	4.2 ± 0.14	4.2 ± 0.14	4.2 ± 0.07	9.63*
Stickiness	3.5 ± 0.14	3.5 ± 0.14	3.8 ± 0.42	4.2 ± 0.21	4.2 ± 0.07	15.8**
Firmness	4.4 ± 0.07	4.2 ± 0.14	4.3 ± 0.07	4.2 ± 0.14	4.2 ± 0.14	25.2**
Bulkiness	4.5 ± 0.07	4.2 ± 0.14	4.2 ± 0.14	4.0 ± 0.35	4.4 ± 0.21	33.6**
Overall acceptability	4.5 ± 0.07	4.2 ± 0.07	4.0 ± 0.07	3.8 ± 0.21	4.0 ± 0.21	16.6**

The mean scores of sensory evaluation showed that all the extruded products prepared from composite blends were within the acceptable range, while the extruded product prepared from composite flour sample-T1 had significantly better colour (4.5±0.07), texture (4.3±0.14), taste (4.5±0.07), stickiness (3.5±0.14), firmness (4.4±0.07), bulkiness (4.5±0.07) and overall acceptability (4.5±0.07). It was revealed from the scores of the overall acceptability that the sorghum + wheat (50:50%) can be successfully developed to produce a better acceptable product.

Development and standardization of sorghum vermicelli

Sorghum vermicelli was developed using sorghum and wheat as main ingredients. The formulations used were given in table 39. Organoleptic characteristics showed that all the products developed with sorghum and wheat showed good acceptability. However, formulation T1 and T3 scored higher than other formulations (Fig.24). Effect of drying temperature on moisture content of sorghum vermicelli was also assessed. Moisture content was decreased with the increase in drying temperature and drying time (table.40).

Table 39: Formulations used for preparation of sorghum pasta

S.No	**Treatment**	**Ingredients**	**Formulation (%)**
1	T1	S+W	50:50
2	T2	S+W	60:40
3	T3	S+W	70:30
4	T4	S+W	80:20
5	T5	S	100

(Sorghum Semolina, Wheat Semolina: S+W)

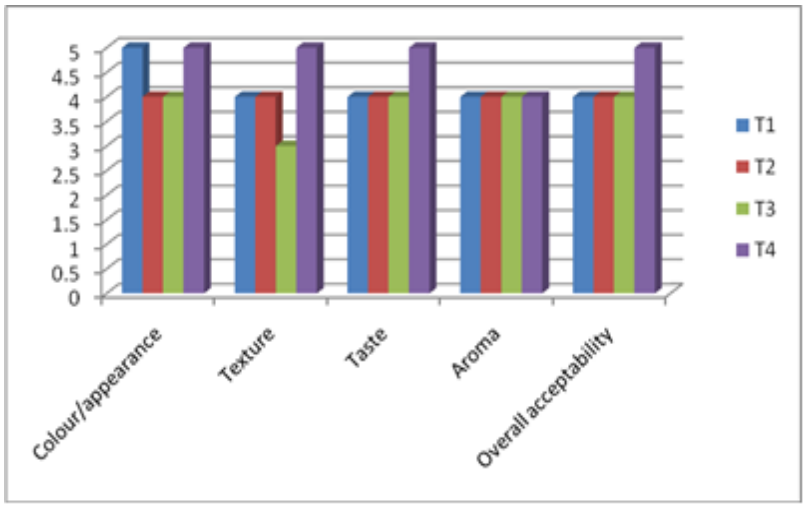


Fig 24: Sensory evaluation of sorghum vermicelli

Table 40: Effect of drying temperature on moisture content of sorghum vermicelli

Sample Code	Time (min)	Temperature (^{0}C)	Mean ±SD
T1	10	40	10.28± 0.04
	20	50	9.61±0.02
	30	60	8.65±0.00
T2	10	40	10.34±0.03
	20	50	9.4±0.01
	30	60	8.37±0.08
T3	10	40	10.1±0.01
	20	50	9.35±0.03
	30	60	8.37±0.2
T4	10	40	9.9±0.65
	20	50	9.09±0.02
	30	60	8.11±0.02
T5	10	40	9.86±0.13
	20	50	9.21±0.02
	30	60	8.67±0.06

Development and standardization of sorghum lassi (DSR with NDRI)

Sorghum lassi was prepared by DSR with collaboration of National Diary Institute, Karnal. The three sorghum cultivars (M35-1, VJH and PV) were selected to prepare lassi. The procedure followed for the preparation of sorghum salt and sweet lassi is given in fig. 25. The study revealed that the germination helped in reducing the content of phytic acid (anti-nutritional factor) to greater extent and significantly enhanced the protein content of sorghum grain. Sorghum lassi (sweet) prepared without stabilizer had superior organoleptic property compared

to lassi prepared with stabilizer. Lassi prepared with germinated sorghum flour of M35-1 was more acceptable than others (VJH and PV) in terms of physico-chemical and organoleptic properties. Acceptable sorghum lassi can be prepared from germinated sorghum flour of M35-1 and can be explored for commercialization.

Table 41: Nutritional profile of raw sorghum flour vs germinated and pearled sorghum flour

S.No	Parameter	Type of sorghum (Flour)	Cultivar		
			M35-1	VJH	PV
1	Moisture(%)	Raw	7.76	8.67	9.04
		Germinated and pearled	8.06	7.08	5.65
2	Protein (%)	Raw	9.39	11.24	12.10
		Germinated and pearled	9.42	11.37	12.56
3	Fat (%)	Raw	2.74	3.12	1.77
		Germinated and pearled	0.59	1.34	0.94
4	Ash (%)	Raw	1.18	1.31	1.85
		Germinated and pearled	0.29	0.69	0.46
5	Phyticacid (g/100g)	Raw	1.08	1.83	1.64
		Germinated and pearled	0.15	0.41	0.33

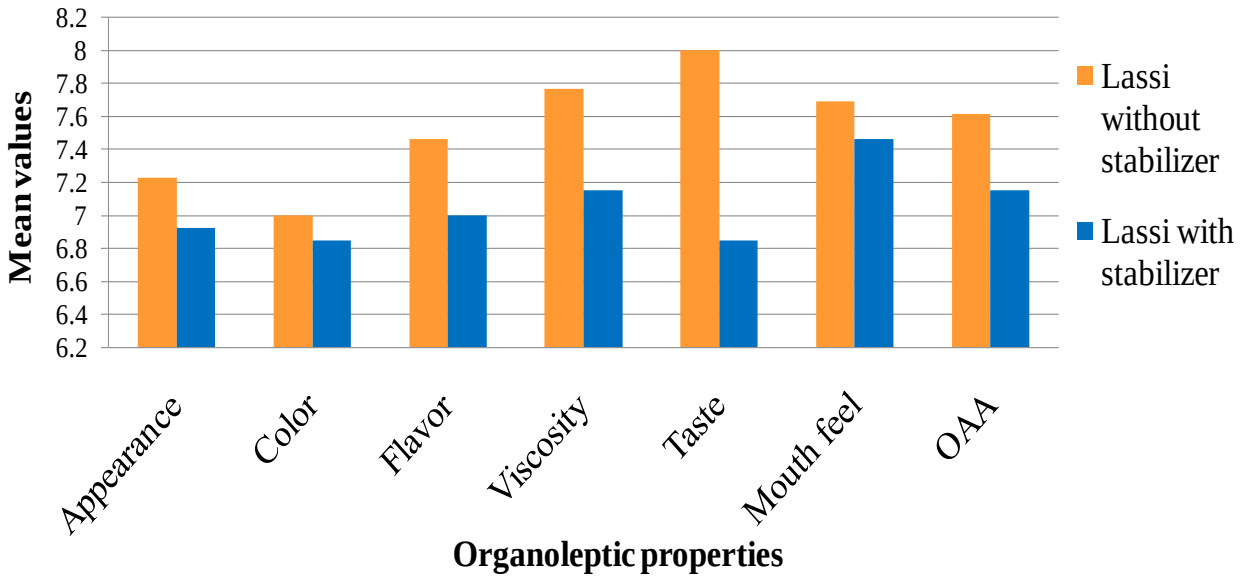


Fig 25: Sensory evaluation of sorghum sweet lassi

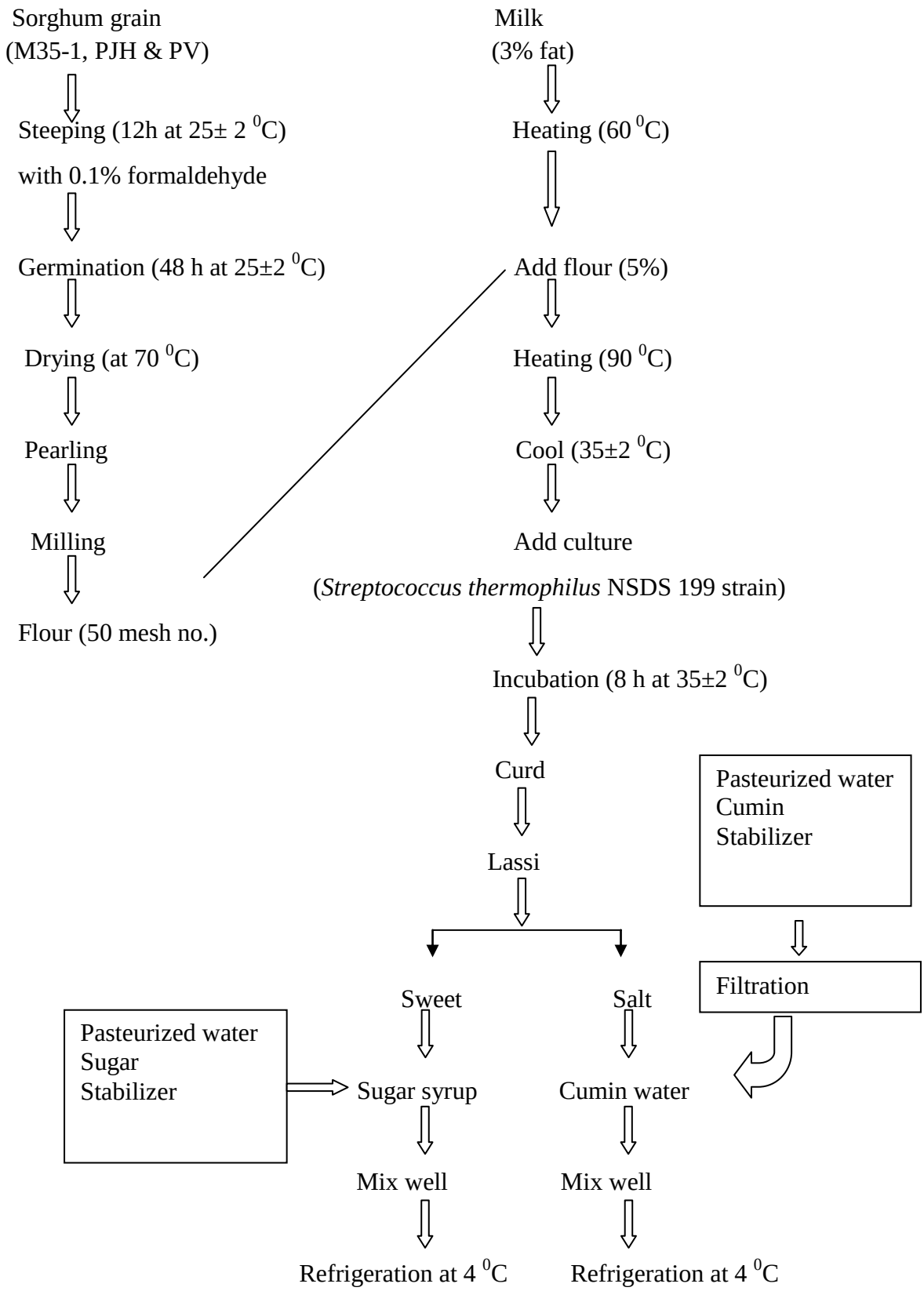


Fig 26: Flow chart for preparation of sorghum lassi

Instant Mixes

Instant and ready to reconstitute foods have become well established products in western countries. In a busy and fast moving life where the house wife is also a bread – earner, instant products have their own importance with the emergence of new technologies and increased per capita income of Indian population, it is the need of the hour to develop traditional foods as convenience foods. DSR has carried out research in developing sorghum based instant and ready to reconstitute foods under this program.

Instant Jowar *Idli* Mix

To prepare jowar idli mix sorghum fine semolina, blackgram dhal, salt, citric acid and sodium bicarbonate were used as main ingredients. Sorghum fine semolina (180µm) and black gram dhal powder (2:1), citric acid (5g), salt (6g) and sodium bi carbonate (6g) were mixed uniformly in a blender. The formulated mix was packed in a MPET packing material. The shelf life of *idli* mix is 3 months. A study conducted by DSR shows that instant *idli* mix has high amount of calcium, iron, zinc and riboflavin when compared to control *idli* (Jowar *Idli*) and protein, magnesium and folic acid content was almost similar to that of control *idli* .

Table 42: Nutritional Composition of Instant *Idli* and Control *Idli*

S.No	Nutrients (100g)	Instant *Idli*	Control *Idli*
1	Energy (kcal)	364.0	346.0
2	Carbohydrates (g)	71.7	72.0
3	Protein (g)	12.4	12.5
4	Fat (g)	1.6	0.8
5	Riboflavin (mg)	1.5	0.1
6	Folic acid (µg)	45.7	49.3
7	Calcium (mg)	10.2	5.8
8	Iron (mg)	7.2	0.2
9	Zinc (mg)	0.9	0.2
10	Magnesium (mg)	102.3	103.3

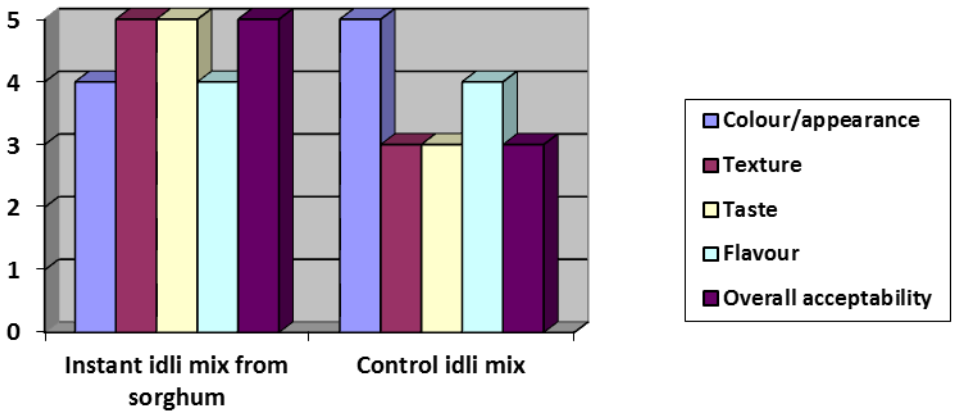


Fig 27: Sensory evaluation of sorghum Instant idli mix with rice idli mix

Instant *Dhokla* Mix

To prepare jowar *dhokla* mix sorghum fine rawa, blackgram dhal, Bengal gram dhal, salt, citric acid and sodium bicarbonate were used as main ingredients. Sorghum fine rawa (180µm)and black gram dhal powder (180µm; 1:1), Bengal gram dhal (22g) citric acid (2.8g), salt (4.6g) and sodium bi carbonate (4g) were mixed uniformly in a blender. The formulated mix was packed in a MPET packing material. The shelf life of *dhokla* mix is 3 months. Instant *dhokla* mix made from jowar is rich in riboflavin, calcium, iron, zinc and magnesium when compared to control *dhokla (Bengal gram flour Dhokla)* and carbohydrates, protein, fat and folic acid was almost similar to that of control *dhokla.*

Table 43: Nutritional Composition of Instant Jowar *Dhokla* mix and Control *Dhokla*

S.No	Nutrients (100g)	Instant *Dhokla* mix	Control *Dhokla*
1	Energy (kcal)	352.0	350.0
2	Carbohydrates (g)	67.8	66.5
3	Protein (g)	15.7	17.5
4	Fat (g)	1.9	1.5
5	Riboflavin (mg)	1.1	0.1
6	Folic acid (µg)	75.2	74.1
7	Calcium (mg)	10.9	8.2
8	Iron (mg)	5.0	0.3
9	Zinc (mg)	0.7	0.1
10	Magnesium (mg)	116.7	71.4

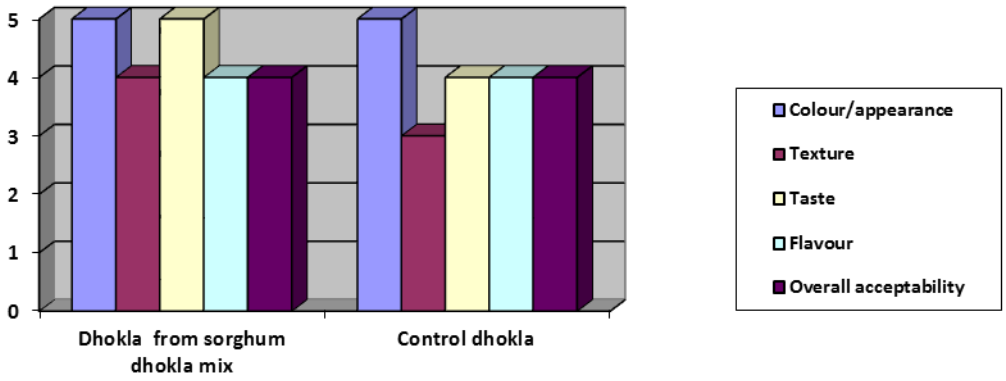


Fig 28: Sensory evaluation of dhokla mix

Instant Upma Mix

To prepare jowar *upma* mix sorghum semolina (500 µm; 100g), Bengal gram dhal (2g), mustard seeds (0.5g), curry leaves (0.3g), dried green chillies (0.8g), dried ginger (0.6g), salt (3g), citric acid (0.2g) and oil (10g) were used as ingredients. Semolina, mustard seeds and Bengal gram dal were roasted separately. To the semolina, roasted mustard seeds, Bengal gram dal, dehydrated

curry leaves, ginger, salt and citric acid were added and mixed. The formulated mix was packed in a MPET packing material. The shelf life of *upma* mix is 6 months.

Instant *Dosa* Mix

To prepare jowar *dosa* mix sorghum flour, blackgram dhal (2:1) salt (6g), citric acid (5g) and sodium bicarbonate (6g) were used as main ingredients and mixed uniformly in a blender. The formulated mix was packed in a MPET packing material.

Sorghum Bran Peda

Bran powder (45g) , sugar (25g), ghee (14.5g), milk powder (15g), and cardamom (0.5g) are sed as main ingredients. The peda can be stored for 7 days at room temperature.

Recipe

- Roast the sorghum bran and grind it to fine powder.
- Add sugar, milk powder and cardamom powder to bran powder and mix well.
- Add ghee slowly to the flakes powder and make in to small balls.
- Decorate with cashew or badam.

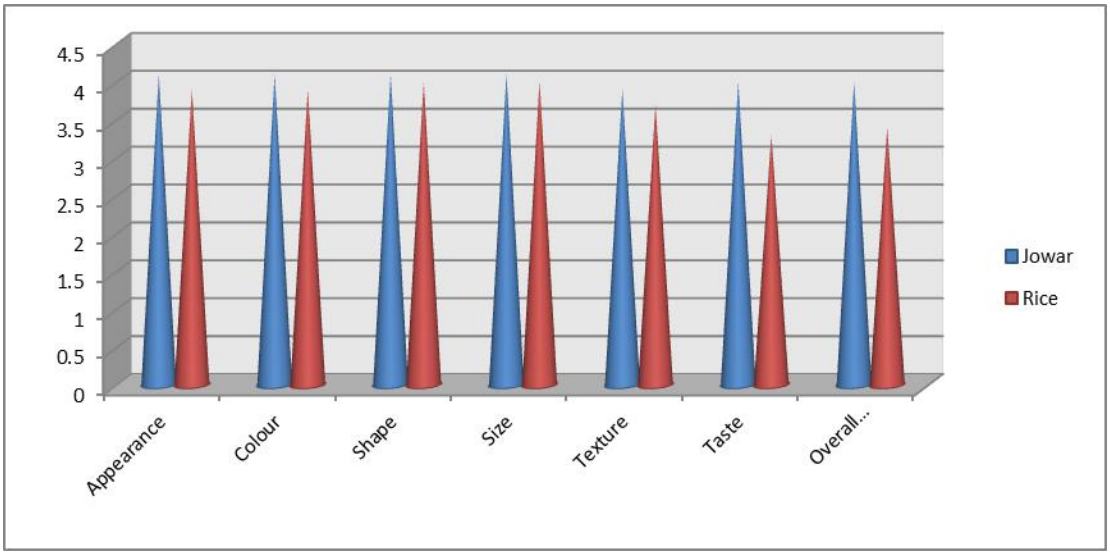


Fig 29: Sensory evaluation of sorghum bran pedha

Instant vermicelli Kheer Mix

The following formulation was standardized to prepare instant vermicelli kheer mix.

Ingredients	Amount (%)
Sugar	61
Vermicelli	30
Raisins	1
Edible vegetable oil	2
Cashewnuts	1
Edible starch	4.5
Cardomom	0.5

Orgnaoleptic evaluation showed the acceptability of sorghum instant vermicelli mix is far better than wheat vermicelli kheer mix (Fig.30) and it can be stored for a period of 6 weeks as it was evident from alcohol acidity (Fig.31).

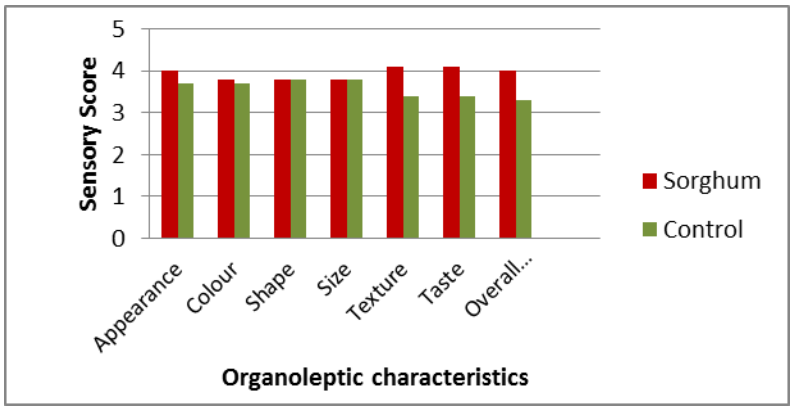


Fig 30: Sensory evaluation of instant sorghum vermicelli kheer mix

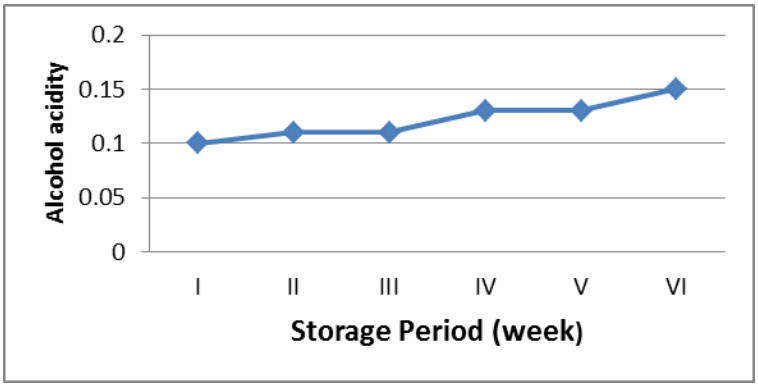


Fig 31: Alcohol acidity of instant sorghum vermicelli kheer mix

Instant Flakes Kheer Mix

The following formulation was standardized to prepare instant flakes kheer mix.

Ingredients	Amount (%)
Sugar	61
Flakes	30
Raisins	1
Edible vegetable oil	2
Cashewnuts	1
Edible starch	4.5
Cardomom	0.5

Orgnaoleptic evaluation showed the acceptability of sorghum instant flakes kheer mix is far better than control kheer mix (Fig.32) and it can be stored for a period of 6 weeks as it was evident from alcohol acidity (Fig.33).

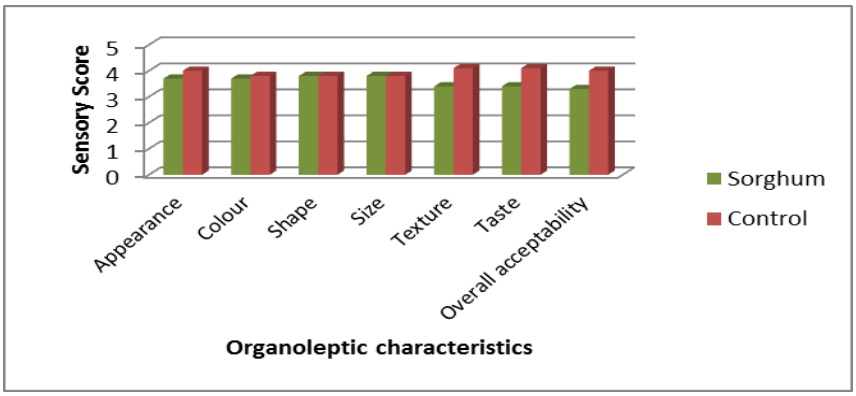


Fig 32: Sensory evaluation of instant sorghum flakes kheer mix

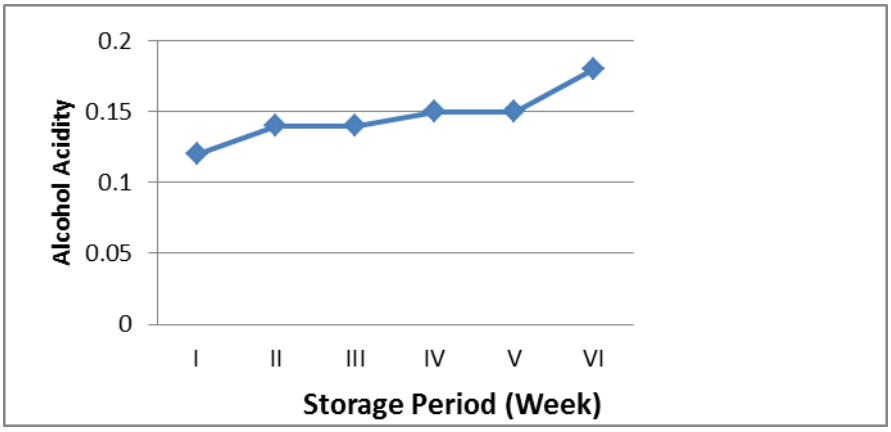


Fig 33: Alcohol acidity of instant sorghum flakes kheer mix

Protein rich snacks

Protein rich snacks were developed with sorghum flour, rice flour, defatted soy flour, flax seeds, sesame seeds and spices. The formulation is given in table 44.

Table 44: Formulations used for the preparation of protein rich snacks

Treatments	Ingredients							
	Sorghum flour	Rice flour	Defatted soy flour	Red chilli powder	Jeera powder	Sesame seeds	Curry leaves + coriander leaves	Flax seeds
T1	50g	20g	30g	2g	1g	7g	1g	3g
T2	70g	-	30g	2g	1g	7g	1g	3g
T3	100g	-	-	2g	1g	7g	1g	3g

Sensory scores showed that the appearance, product prepared from T1sample was better than other products. In terms of texture T3 was better than others, in terms of taste and texture T2 was better than others, but in terms of overall acceptability sample made out of flour blends of 50% sorghum flour + 20% rice flour + 30% defatted soy flour was good than other two products.

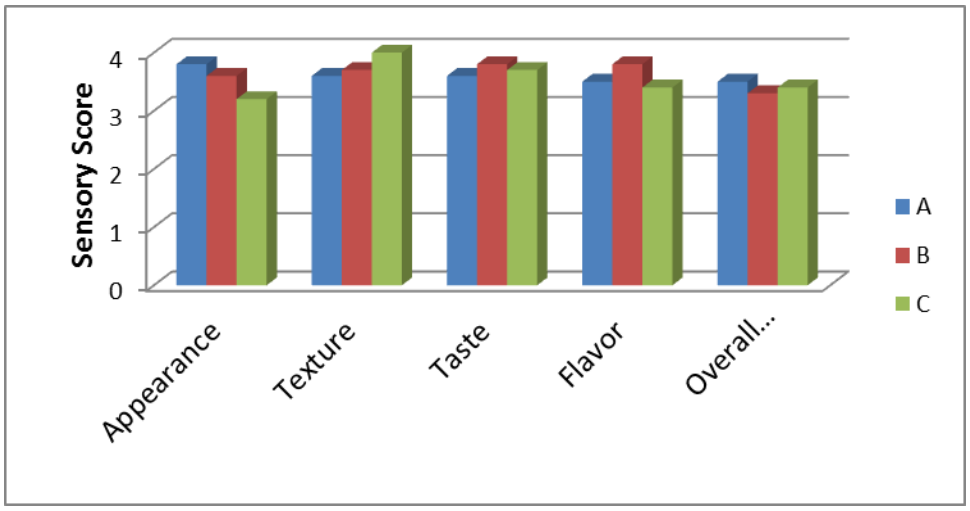


Fig 34: Sensory evaluation of protein rich snacks

Formulation of masala for the preparation of sorghum flakes and pops

Aam chat masala, pudina seasoning and coriander masala were developed and standardized for masala sorghum flakes and pops preparation. The flow chart for the preparation of masala and masala flakes/ pos is given in fig. 35.

Table 45: Formulations used for the preparation of aam chat masala and pudina seasoning

Ingredients	AAM chat masala	Pudina seasoning
	Quantity (g)	Quantity (g)
Maltodextrins	29.40	29.40
Salt	12	12
Black salt	4	4
Sugar	18	18
G.chilli	5	5
Cumin	2.50	2.50
Coriander	8.50	8.50
Ginger	1.20	1.20
Black pepper	1	1
Turmeric	1	1
Asafotida	0.02	0.02

Cardamom	0.70	0.70
Cinamom	1.20	1.20
Clove	0.28	0.28
Citric acid	1.50	1.50
Amchur powder	9.50	
Malic acid	0.60	0.60
Pudina oil	0.50	
I+G	3.5	3.5
$Caco_3$	0.10	0.10
Paparika oleoresin	0.30	0.30

Table 46: Formulation of coriander masala for the preparation of sorghum flakes and pops

S.No	**Ingredients**	**Amount (%)**
1	Chilli	3.7
2	Onion Powder	9
3	Cumin	2.1
4	Garlic	5
5	Coriander	15.64
6	Turmeric	2.9
7	Aniseed	0.05
8	Black Pepper	0.3
9	Fenugreek	0.03
10	Ginger	1.8
11	Clove	0.2
12	Nut meg	0.08
13	Cardamom	0.1
14	Paprika Extract	0.3
15	Iodized Salt	16.7
16	Sugar	13
17	Sorghum flour	7.4
18	Edible Vegetable Oil	3
19	KCl	1
20	I+G	0.8
21	Citric Acid	0.5
22	Malto dextrins	16.4

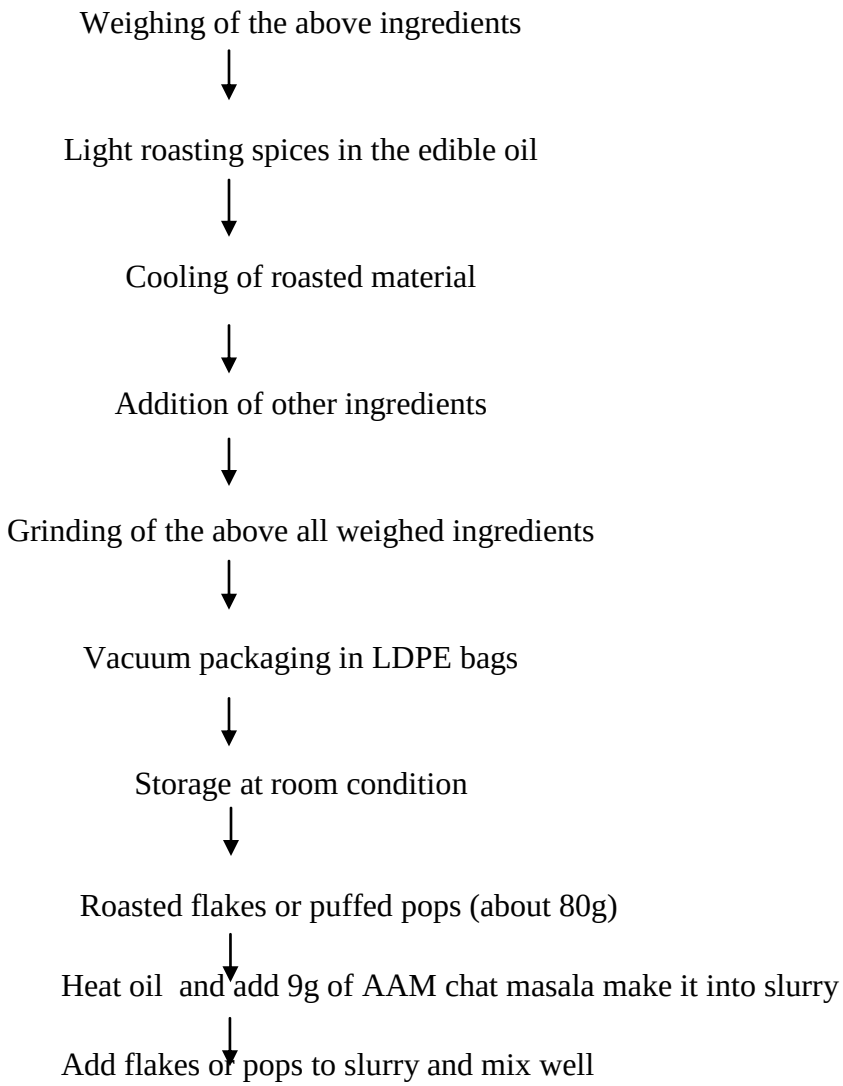


Fig 35: Flow chart for the preparation of masala flakes/ pops

Standardization of taste makers for pasta

Tomato and masala tastemakers were standardized for sorghum pasta . The procedure includes roasting and grounding of spices and condiments and addition of onion powder, garlic, sorghum flour, Kcl, sugar, citric acid, maltodextrins and salt etc. The paprika extract was added to the above mix, and mixed well. Organolpeic evaluation was also conducted as commercial pasta/ noodles tastemaker as control. Sensory scores show that the DSR formulations had higher acceptability than commercial taste makers

Table 47: Formulation of taste makers for pasta

S. No	Tomato		Masala pasta	
	Ingredients	**Amount (%)**	**Ingredients (%)**	**Amount (%)**
1	Tomato Powder	22	SMP	22
2	Sugar	17	Sweet whey powder	14.2
3	Salt	12	Onion Powder	11.5
4	Milk Solids	14	Coriander	3.3
5	Sweet whey powder	4.4	Coriander leaves	1.8
6	Onion Powder	3	Garlic	3.1
7	Onion flakes	4.3	Turmeric	2.3
8	Green Bell pepper	7.1	Chilli	0.5
9	Malto dextins	1	Cumin	0.1
10	Garlic granules	2.8	Aniseed	0.05
11	Edible vegetable oil	1.5	Black pepper	0.35
12	Corn flour	2	Fenugreek	0.03
13	Potassium chloride	1	Ginger	0.07
14	Cumin	1.2	Paprika extract	0.4
15	Paprika extract	0.5	Clove	0.1
16	Black pepper	1	Nutmeg	0.03
17	G. Chilli	1.6	Green cardamom	0.1
18	Oregano	0.9	Sugar	9.5
19	I+G	1.2	Sorghum flour	5.1
20	Malic Acid	0.4	Corn flour	3.1
21	CaCO3	0.8	Salt	11.2
22	Cream Plus Butter buds	0.3	**Malto dextrins**	**4**
			I+G	1.2
			Edible Vegetable oil	2
			Kcl	1
			Citric acid	0.3
			CaCO3	0.8
			Butter buds supreme	0.3
			Butter buds asia	0.5
			Mustard ®	0.07
			Soya bean	1

Associate partner: CFTRI, Mysore Processing Interventions

Enhancing shelf life of sorghum flour and multigrain flour

AT CFRTI, shelf life of sorghum flour was assessed using infrared heating. Central composite design was used to optimize infrared heating parameters, using 80-120°C temperature for 5 - 15min duration. Free fatty acids, lipase enzyme activity and peroxidase enzyme activity were estimated using neutral alkaline method, titremetric method and spectophotometric methods respectively. Pasting profile of native and treated samples was studied using Brabender Micro Amylograph for 10 % slurry concentration. Colour was measured using Hunter colour measuring system. Processing time of 8.5 min at a temperature of 120^{o}C were obtained as optimum conditions for lowest free fatty acid content(0.03%), lipase activity(10 µeq.mg/h) and peak viscosity value (294BU). A high R2 value for above response (96.24%, 97.74% and 90.87%, respectively) suggests that the model is a good fit. Sorghum flour processed at 120^{o}C for 8.5mins exhibited 70.98% and 15.1% decrease in moisture content and peroxidase enzyme activity respectively compared to native flour. Colour of native and treated flours i.e., whiteness(L) and average colour value(ΔE) ranged from 97.42-87.65 and 13.06-14.13 respectively. Pasting indices i.e.,hot peak viscosity and cold paste viscosity ranged from 272-248BU and 582-511BU respectively. Results convey that sorghum flour treated under infrared heating for 8.5mins at 120^{o} can have a desirable storage stability whereas actual storage study for shelf stable sorghum flour is required and it is in progress.

Table 48: Shelf life of sorghum flour with Infrared treatment

Native	**FFA%**	**Peroxidase (od at 470nm)**	**Lipase (µeq.mg/h)**	**Moisture (%)**
	0.2±0.14	0.644±0.12	90±0.02	15.810±0.02
80°C-10mins	0.15±0.07	0.63±0.30	85±0.02	8.176±0.02
86°C -6.5min	0.14±0.01	0.661±0.14	85±0.03	9.582±0.14
86°C -13.5min	0.12±0.02	0.6675±0.14	70±0.01	7.317±0.12
100°C -5min	0.15±0.01	0.620±0.20	80±0.01	8.260±0.05
100°C -10min	0.11±0.02	0.6315±0.21	70±0.20	6.275±0.02
100°C -15min	0.08±0.02	0.621±0.22	65±0.01	4.676±0.41
114°C -6.5mins	0.07±0.14	0.6015±0.20	45±0.05	6.085±0.00
114°C -13.5	0.04±0.14	0.522±0.12	20±0.05	5.034±0.04
120°C -10mins	0.03±0.00	0.526±0.16	10±0.21	4.788±0.04

Table 49: Colour values of Infrared treated sorghum flour

	L*	ΔE
Native	88.73	13.06
80°C -10mins	88.57	13.27
86°C -6.5min	88.76	13.11
86°C -13.5min	88.23	13.56
100°C -5min	88.54	13.09
100°C -10min	88.58	12.97
100°C -15min	88.52	13.24
114°C -6.5mins	88.44	13.47
114°C -13.5	88.54	13.15
120°C -10mins	87.65	14.12

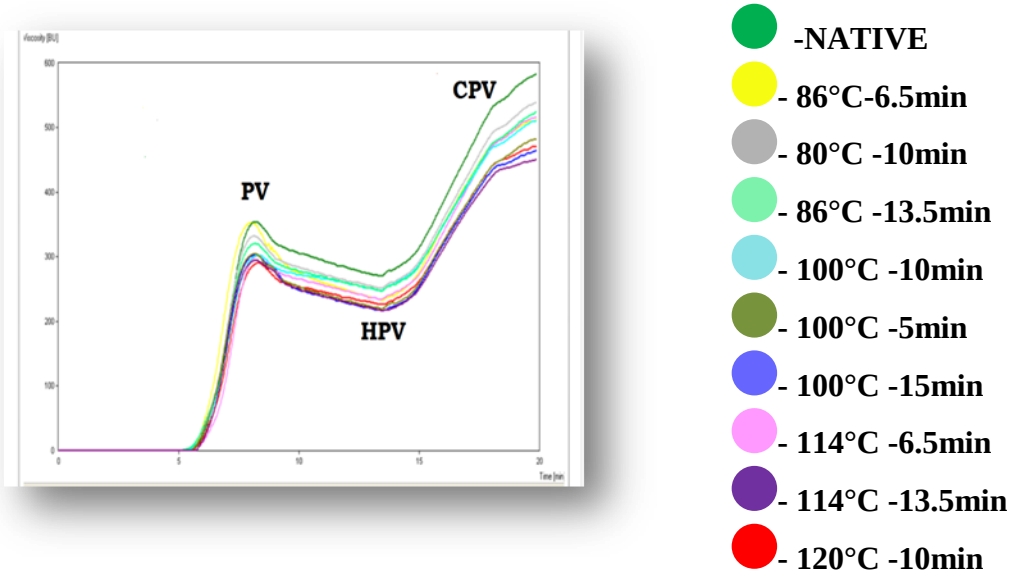


Fig 36. Pasting profile of Infrared treated sorghum flour

Fig 37: Surface plot showing effect of infrared heating on peak viscosity, lipase and free fatty acids

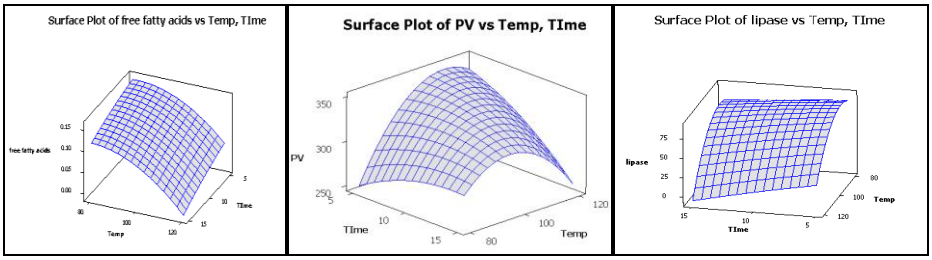
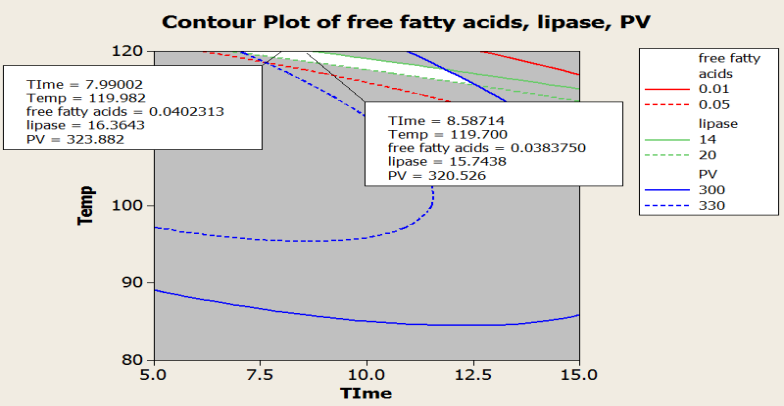


Fig 38: Counter plot showing effect of infrared heating on peak viscosity, lipase and free fatty acids



Development of pasta from sorghum

Sorghum pasta were prepared by blending with by blending sorghum flour separately with soya protein concentrate (SPC) and channa flour along with gaur gum and also from using sorghum alone (Native sorghum pasta). The control pasta was prepared using 100% durum wheat (Control Pasta) to compare the quality parameters with sorghum pasta. Pasta was analyzed for the proximate composition, dietary fibre, protein digestibility, carbohydrate digestibility, cooking loss and gel consistency. Pasting profile, texture, color and sensory of pasta were also evaluated. The storage studies of sorghum pasta are continuing.

Cooking quality of the pasta revealed that sorghum pasta with different blends exhibited more cooking loss (6-14%) than that of durum wheat (control) pasta (5%). Protein, ash and fat content in pasta made with incorporation of SPC and channa increased compared to control and native sorghum pasta. The gel consistency of cooked sorghum pasta (113-152mm) showed significantly higher value compared to blends as such (30-115 mm). Pasting indices i.e., peak viscosity, hot past viscosity and cold past viscosity of sorghum pasta ranged from 160-337 BU, 118-250 BU and 254-536 BU respectively. The colour of pasta i.e., whiteness (L) and average color value (ΔE) ranged from 53.2-59.2 and 44.9-49.9 respectively. The texture value, in terms of shear force for cutting of cooked pasta ranges from 0.53 to 1.26 N. The shear force for native sorghum pasta showed 0.53N and this was improved to 1.26 N by blending with channa and gaur gum. Results are useful to prepare sorghum pasta and could be used for commercial adaption.

Table 50: Proximate composition of sorghum pasta

Sample	Protein (g/100g)	Moisture (g/100g)	Fat (g/100g)	Ash (g/100g)
I F	13.5±0.44	8.1±0.15	4.4±0.40	1.3±0.14
II F	12.7±0.43	7.7±0.19	5.1±0.13	1.3±0.20
III F	13.6±0.38	7.8±0.20	6±0.14	0.7±0.47
IV F	12.5±0.35	7.7±0.49	1±0.12	0.6±0.05
V F	9.3± 0.28	7.8±0.57	3.3±0.25	1±0.17

Table 51: Quality characteristics of Sorghum Pasta

Sample	Cooking time (min)	Cooked wt (g)	cooking loss (g/100 g)	IVSD (g/100 g)	IVPD (g/100 g)	Shear force (N)
I F	3.2±0.1	47.6±1.5	6.4±0.6	20.1±0.16	93.1±0.8	1±0.01
II F	3.1±0.2	52.2±2.5	5.8±0.1	19.6±0.5	94.7±0.5	1.1±0.2
III F	3.3±0.2	52.3±0.9	5.8±0.2	18.8±0.3	95.4±0.8	1.3±0.2
IV F	4.7±0.3	51.6±0.8	5.5±0.1	18.8±0.2	91.3±0.7	1.5±0.1
V F	3.1±0.1	50.1±2.5	14.2±0.4	22±0.5	81.2±0.6	0.5±0.2
IVSD : In-vitro starch digestibility, IVPD : In-vitro protein digestibility						

Table 52: Colour Parameters of Sorghum Pasta

Sample	L*	a*	b*	ΔE
I F	57.2	4.7	21.9	46.2
II F	54.6	3.5	20.3	47.7
III F	53.7	4.1	21	48.8
IV F	66.3	1.8	21.1	37.8
V F	53.8	4.7	21.1	48.9

IF – Sorghum + SPC, IIF – Sorghum + Channa
IIIF – Sorghum + Channa + Gaurgum, IV – Control (Wheat) V – Native (Sorghum)

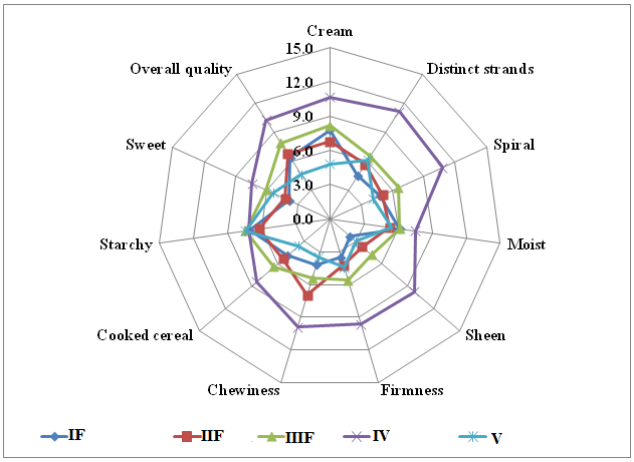
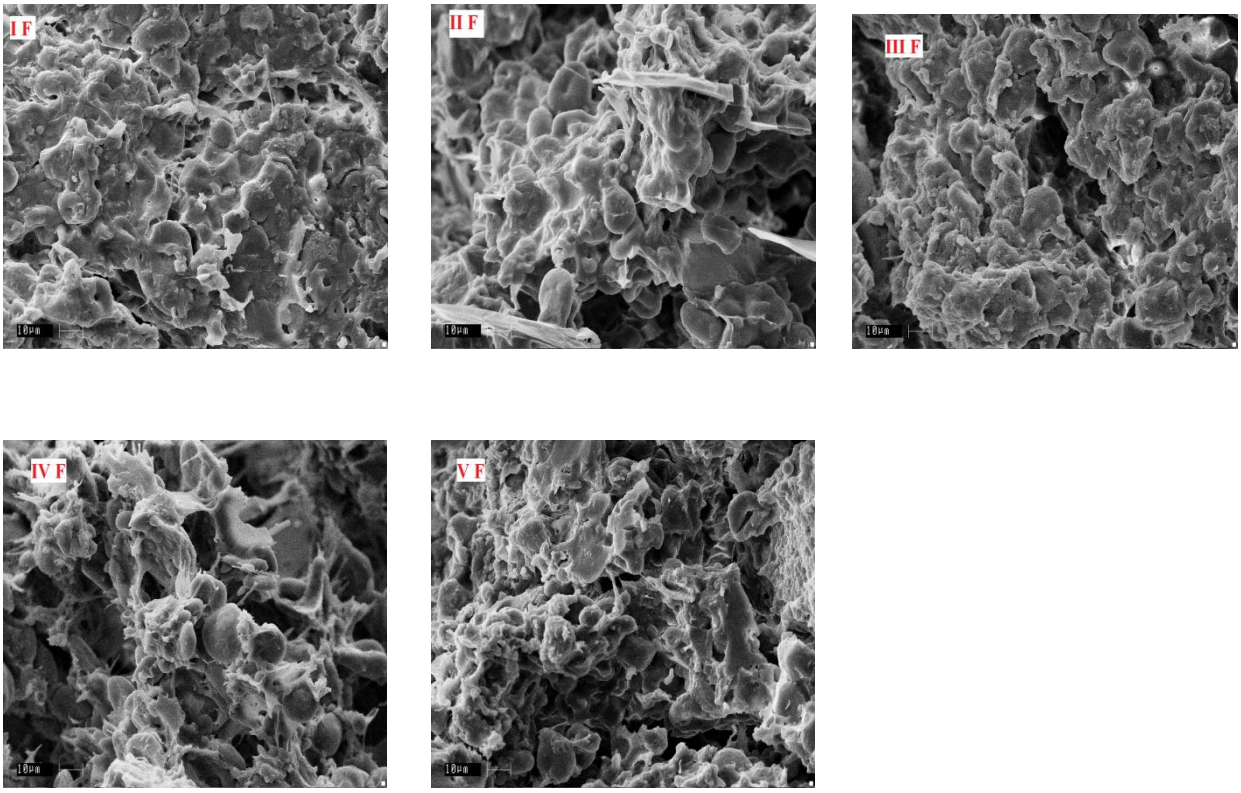


Fig 35: Sensory analysis of sorghum pasta

SEM Microphotograph of Different Pasta Blends



SEM microphotography depicted distinctly change in their granular structure for different blended sorghum pasta.

E. Nutritional Evaluation

Nutritional evaluation and certification of sorghum foods was done at National Institute of Nutrition (ICMR), Hyderabad. National Institute of Nutrition, Hyderabad has worked on the below mentioned areas

1. Nutritional composition of sorghum processed foods
2. Evaluation of organoleptic properties of sorghum based Indian traditional breakfast and snack recipes
3. Glycemic index and glycemic load of sorghum foods
4. Effect of sorghum diet on glycosilated hemoglobin and lipid profile in people suffering from diabetes
5. Effect of sorghum diet on nutritional status of school going children
6. Amino acid profile of sorghum processed foods
7. Determination of protein efficiency of sorghum

Nutritional composition of sorghum processed foods

Sorghum processed products such as flour, multigrain flour, coarse, medium and fine semolina, flakes, pasta, vermicelli and biscuits were evaluated for its nutritional composition. Nutrients such as energy, carbohydrates, protein, fat, fibre, ash, moisture, total caroteniods, beta carotene, B–vitamins, vitamin-C, calcium, iron, zinc, copper, manganese, magnesium, phosphorus, magnesium and molybdenum were estimated with standard methods (Table.53). All the sorghum based foods are rich in energy, serving 330kcal to 481 kcal. The available carbohydrate content was higher in sorghum pasta followed by flakes, semolina, flour, multigrain flour and biscuits. Protein, total dietary fibre, soluble fibre and insoluble fibre content were higher in multigrain flour. B-vitamins such as thiamin, riboflavin, niacin and total folic acid were higher in multigrain flour. Among the minerals, the higher amount of calcium was found in biscuits, copper in multigrain flour and iron, zinc, phosphorus, magnesium and manganese in pure sorghum flour.

Table 53: Nutritional composition of sorghum processed foods

S.no	Name of the Sample	Jowar flour (217.1)	Jowar pasta (217.2)	Jowar flakes (217.3)	Jowar rawa (217.4)	Jowar soya blend (217.5)	Jowar biscuits (217.6)
A. Proximate Composition(g/100g)							
1	Moisture	8.25	8.68	10.55	8.72	7.89	2.76
2	Total Ash	1.33	0.69	0.70	0.90	1.64	2.21
3	Protein	8.76	9.50	7.23	9.79	11.92	6.70
4	Fat	3.24	1.22	1.79	2.87	2.62	23.72
5	Total Dietary fibre	9.69	5.56	5.97	9.23	12.71	5.27
6	Insoluble Dietary fibre	8.1	4.82	5.43	7.92	9.77	3.54
7	Soluble Dietary fibre	1.59	0.74	0.54	1.31	2.94	1.73
8	carbohydrates	68.73	74.35	73.76	68.49	63.22	59.34
	energy	342	348	341	342	330	481
B. Minerals(mg/100g)							
1	calcium	15.42	16.99	10.94	8.81	25.41	68.83
2	magensium	140.24	54.32	68.87	79.61	62.90	92.23
3	copper	0.15	0.43	0.10	0.18	0.22	0.25
4	manganese	1.01	0.66	0.53	0.91	1.44	0.57
5	iron	3.52	2.90	3.44	1.84	3.03	2.02
6	zinc	1.69	0.98	0.88	0.96	1.06	1.69
7	phosphorus	170.02	110.27	110.02	150.22	85.14	107.66
8	Molybdenum	ND	ND	ND	ND	ND	ND
C. Vitamins(mg/100g)							
1	thiamine	0.32	0.19	0.18	0.23	0.45	0.23
2	Niacin	1.92	1.15	1.28	1.58	1.93	1.90
3	Riboflavin	0.13	0.11	0.11	0.12	0.15	0.17
4	Total carotenoids	ND	ND	ND	ND	ND	ND
5	Beta- carotene	ND	ND	ND	ND	ND	ND
6	Total folic acid	958.03	732.67	657.8	1283.17	1569.36	547.01
7	Vitamin C	ND	ND	ND	ND	ND	ND

Evaluation of organoleptic properties of sorghum based Indian traditional breakfast and snack recipes

Organoleptic properties and nutrient composition of sorghum based Indian traditional breakfast recipes viz., *roti, idli, dosa and upma* and snacks recipes viz., *muruku, vada, pakoda, chekkalu, chegodi and punugulu* were evaluated and compared with the standard wheat or rice based recipes. Recipes were carefully prepared according to the procedures mentioned in 'Delicious Sorghum Foods' by Ratnavathi et al. (2008). *Idli* was prepared with sorghum fine semolina (250µm) and black gram dhal (3:1), *dosa* was prepared with dehulled sorghum grain and black gram dhal (3:1), r*oti* was prepared using **s**orghum flour (180 µm) and upma was prepared with medium size particle semolina (500µm) and spices. *Muruku, chekkalu and pakoda* were prepared with sorghum flour, Bengal gram flour (2:1) and spices whereas; *vada* and *punugulu* were prepared with sorghum flour, black gram dhal (1:2) and spices. *Chegodi* was prepared with sorghum flour, Bengal gram flour (4:1) and spices. Sensory evaluation was carried out by semi-trained judges using a 5-point Hedonic rating scale (*Amerine et al., 1980*) for sensory attributes like colour, appearance, flavour, taste, texture and overall acceptability. Descriptive statistics like mean, standard deviation and frequency distribution were computed for all the attributes. Student't' test was used to know the mean differences between control and test samples.

The panelist's response on organoleptic properties of roti is given in Fig.36 (a). The taste (Test: 3.3 ± 0.96; Control: 4.0 ± 0.78) and overall acceptability (Test: 3.4 ± 0.91; Control: 4.1 ± 0.53) of sorghum *roti* was significantly lesser than the wheat *roti*. The variations may be due to the bland taste of sorghum and can be enhanced by making *roti* with mixed cereal flour. The sensory attributes shows that taste, texture and overall acceptability of sorghum *upma* was significantly lesser ($p<0.05$) than the wheat upma Fig.36(b). The jowar rawa/grits have to be soaked in water for as long as an hour before cooking to make the finished product as soft as wheat *Upma*. The sensory scores reveal that the sorghum *dosa* was liked by the panelists. No significant difference was found for color, shape, size, texture, taste and overall palatability between sorghum *dosa* and control *dosa*. However, appearance of control dosa (3.7 ± 0.49) was significantly higher than the sorghum dosa (3.2 ± 0.72). The significant difference in appearance may be due to the color of the sorghum grain (Fig.36(c). As the study states, color was one of the traits that affects the acceptability of sorghum. The sensory scores reveal that no significant difference was found between sorghum *idli* and control *idli* (Fig.36(d). However, mean values show that color and appearance of control *idli* was higher than sorghum *idli.*

The percentage acceptability of sorghum breakfast recipes is given in fig. 37. Sorghum products were well accepted by 80% of the panelists. The overall palatability of products viz., sorghum *dosa* 83.4%, *Idli* 100%, upma 88.9% and roti was 86.7%. The results of the study clearly show the overall acceptability score of wheat *roti* was 100% and sorghum *roti* was 87%. Sorghum *roti* was prepared from whole millet flour. It lacks gluten and hence the dough does not have stickiness to be rolled, and to make the unleavened bread (flattening the *Roti*). Lack of gluten does not facilitate proper rolling of thin *roti*, as it tends to break. Proper blending with wheat flour at 80:20 or 70:30 can solve the problem and balances the amino acid content to a great extent to prevent primary pellagra. Thus the sorghum preparations can replace the cereal

grains without compromising the sensory attributes. Sorghum semolina *upma* can be given to all age groups as a replacement to traditional upma recipe. The recipes like *dosa* and *idli* are in regular use by the majority of the south Indian population. These recipes are prepared with fermented batter of cereal and pulse. The acceptability of sorghum dosa and *idli* were relatively on par with the control recipes. *Dosa* and i*dli* batter can be prepared from appropriately processed sorghum and made available in large and medium retail stores, so that it can be purchased easily by a large segment of the population.

The cooking method involved in the preparation of snacks recipes was deep fat frying hence the recipes prepared with sorghum and pulse combination was energy dense foods. The calorie content of recipes ranged from 243 K.Cal/ 100g to 550.7 K.Cal /100g and fat content ranged from 4.7g/100g to 35.5g/100g (Table. 54). Among the recipes, energy and fat content was lesser in punugulu and higher in chegodi than the other recipes. All the recipes suits the nutritional demands of growing children as it was evident through energy, and fat content. Punugulu can be consumed by people who are calorie conscious and on reducing diet. The protein content of pakoda was higher and chekkalu was lesser than the other recipes. Pakoda and muruku were prepared with sorghum, pulse and oil seeds combination (2:1:1), punugulu, chegodi and vada were prepared with sorghum and pulse combination (1:2), where as chekkalu was prepared with sorghum and pulse combination (2:1). This could be reason of low levels of protein in chekkalu than the other recipes which have higher level of pulses. The carbohydrate content of vada was lesser and chekkalu was higher than the other recipes. The ratio of pulse was higher than the cereal used in the preparation of vada (Pulse and cereal ratio;1:2). All the recipes were having good amount of calcium. The calcium content of recipes ranged from 26.4 mg/100mg to 230mg/100g. The calcium content was higher in chegodi (230mg/100g) and punugulu (209mg/100g) and lesser in chegodi (26.4mg/100g). Iron and zinc content was higher in pakoda (4.9mg/100g; 1.9mg/100g) and lesser in punugulu (0.8mg/100g; 0.6mg/100g). Adequate amount of magnesium was found in the recipes. The amount of magnesium was higher in chegodi (100mg/100g) and lower in punugulu (340.1mg/100g). The developed recipes were found nutritionally superior in terms of energy, fat, carbohydrate, calcium, iron and zinc. The development of value added products can go in a long way in improving the nutritional status of the population especially children

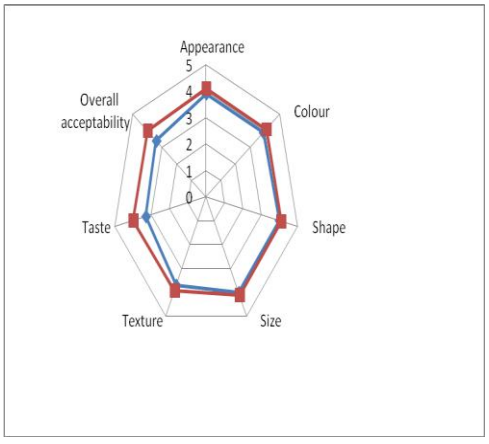


Fig 36 (a) Roti

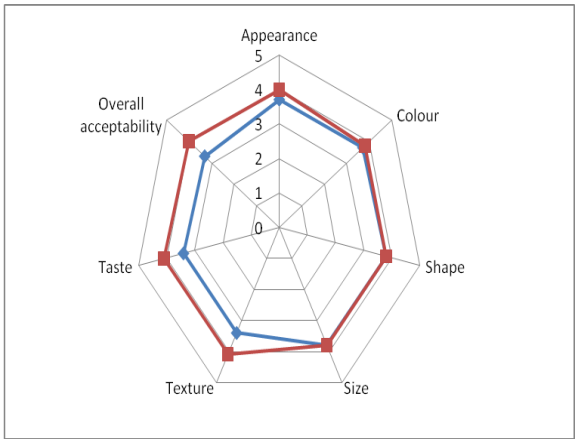


Fig 36 (b) Upma

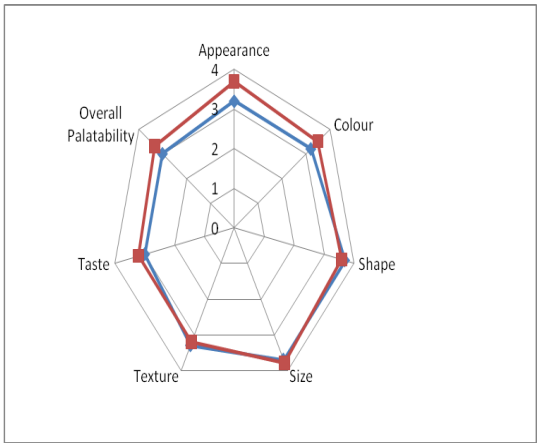


Fig 36 (c) Dosa

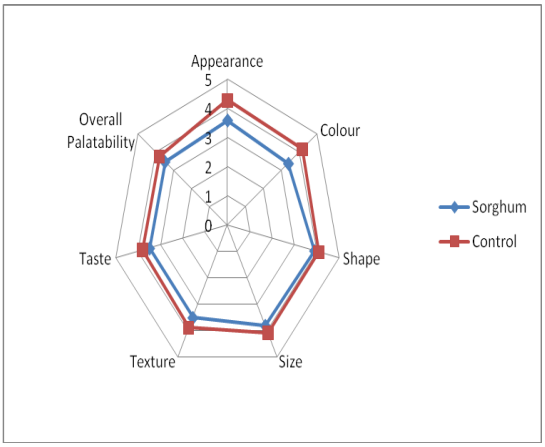


Fig 36(d) Idli

Fig 36: Organoleptic Properties of Breakfast Recipes Prepared from Sorghum

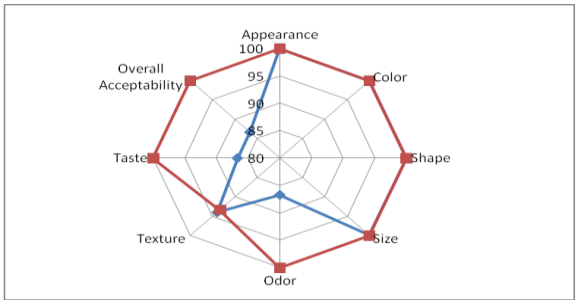


Fig 37 (a) Roti

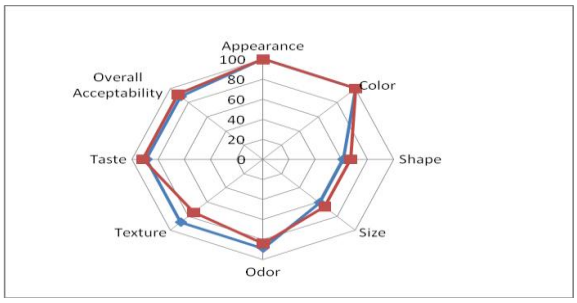


Fig 37 (b) Upma

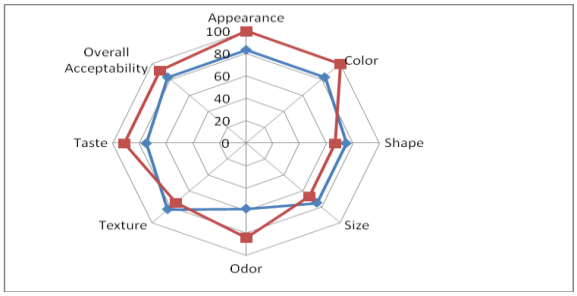


Fig 37 (c) Dosa

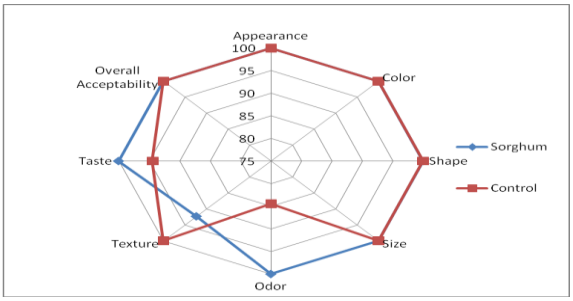
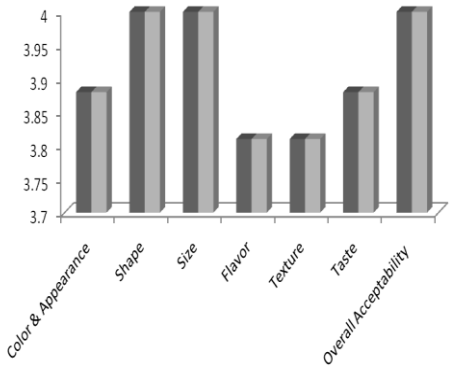


Fig 37 (d) Idli

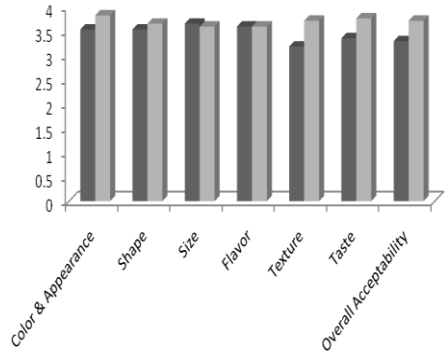
Fig 37: Percentage Acceptability of Breakfast Recipes Prepared from Sorghum

Table 54: Nutrient Composition of Indian Traditional Snack Recipes Prepared from Sorghum

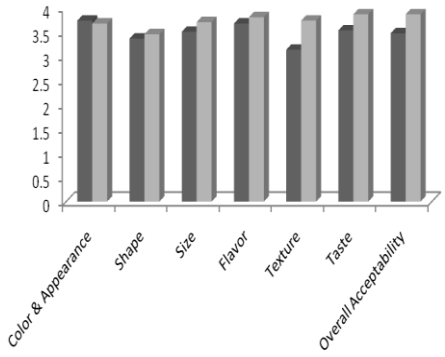
Nutrients/100g	Recipes					
	Muruku	**Vada**	**Pakoda**	**Chekkalu**	**Chegodi**	**Punugulu**
Energy (K.Cal)	528.7	337.1	448.8	519.5	550.7	243.1
Carbohydrates (g)	52.1	31.5	52.3	59.3	51.2	43.2
Protein (g)	6.90	7.1	10.4	4.2	6.6	7.0
Fat (g)	32.5	20.3	22.0	29.5	35.5	4.7
Moisture (g)	6.30	38.5	11.1	3.90	4.30	42.9
Calcium (mg)	26.4	28.8	38.7	30.6	230.0	209.5
Iron (mg)	3.6	2.0	4.99	4.5	2.4	0.8
Magnesium (mg)	75.8	72.5	87.7	71.8	100.0	34.1
Zinc (mg)	1.65	1.30	1.99	1.90	1.15	0.6



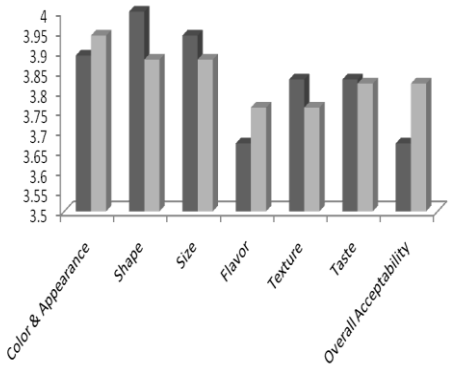
(a) Muruku



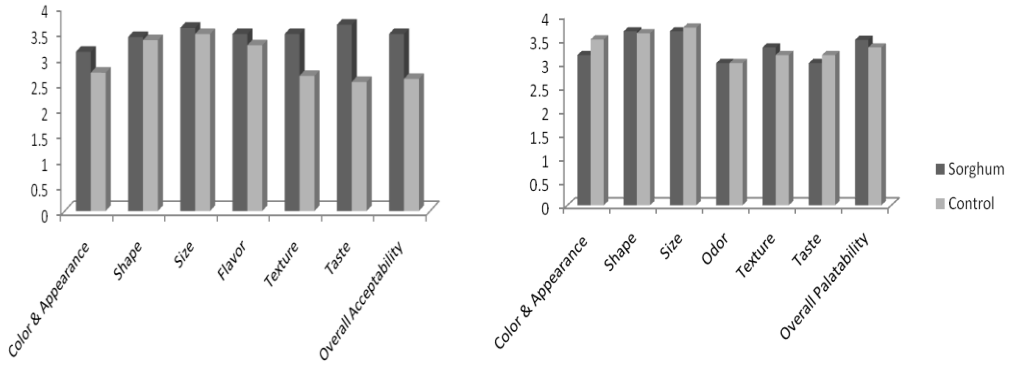
(b) Vada



(c)Pakoda



(d) Chakkalu



(f) Chegodi *(g)Punugulu*

Fig 38: Organolpetic Properties of Indian Traditional Snacks Recipes Prepared from Sorghum

The organoleptic properties such as colour and appearance, flavor, texture, taste and overall acceptability of sorghum *muruku* were good (4.0 $\pm$0.30) and similar to that of control recipe (4.0 $\pm$0.30) (Fig.38a). The appearance, colour, shape, size and flavor of sorghum *vada* and control *vada* were similar. However, the overall acceptability of sorghum *vada* (3.2 ± 0.68) was lesser than the control recipe (3.7 ± 0.47) (fig.38b). The organolpetic properties of sorghum *pakoda* (3.4 ± 0.51) were lesser than the control *pakoda* (3.8 ± 0.36) (fig.38c), whereas colour and appearance, texture and taste of sorghum *chekkalu* was higher than the control recipe (Fig.38d). Sorghum *chegodi* was well accepted as it was evident by the scores obtained from the panelists. The mean overall acceptability and taste of sorghum chegodi (3.4± 0.62) was higher than that of the control *chegodi* (2.5± 0.61) (fig.38e). The color and appearance, flavour, texture, taste and overall acceptability sorghum *punugulu* (3.4± 0.71) were higher than that of the control *punugulu* (3.3± 0.65) (fig.38f).

3. Glycemic index (GI) and glycemic load (GL) of sorghum foods

Sorghum based foods such as multigrain flour, coarse semolina, fine semolina, flakes, pasta and biscuits were evaluated for its GI and GL and were compared with wheat/ rice based foods using standardized methodology. For this study, ten non- diabetic healthy, volunteers, age between 20-40 years were recruited for evaluating each food item. The study was conducted according to the guidelines laid down in the declaration of Helsinki, and all procedures involving human subjects were also approved by the Institutional Ethics Committee of the National Institute of Nutrition, Hyderabad. Raw materials used for the preparation of test foods were prepared at the Directorate of Sorghum Research, Hyderabad and recipes were prepared in the Metabolic Kitchen, National Institute of Nutrition, Hyderabad. 50g available carbohydrate portion of a reference food and test food (sorghum, wheat or rice based recipes) was given in a random order after 8 – 10 hrs over night fast, at least one week apart between the tests. Fasting (-5 and 0 min) and postprandial blood samples were taken from finger prick at 15, 30, 45, 60, 90 and 120 min after the reference or test food feeding to determine the GI and GL of test foods. The protocol used to measure GI was adapted as described by Wolever et al., (1991) and is in line with the procedure

recommended by the FAO/WHO (1998). GL of a specific serving of each food was calculated the formula: GL = GI x the amount of available carbohydrate in a 100g serving / 100. Difference between the test foods was tested by paired't' test. Among the sorghum based foods, the GI of coarse rawa *upma* ($p<0.05$), fine rawa *upma* ($p<0.05$), pasta ($p<0.01$) and *poha* ($p<0.01$) were significantly lower than their respective control food (wheat/rice) and no significant difference was found for multigrain *roti* and biscuits. The GL of all sorghum based foods was lower than that of wheat/ rice based foods (Table.55).

Table 55: +iAUC, GI and GL of Test Foods

Foods	+ iAUC (mg/dl)		GI		GL	
	Sorghum	**Wheat**	**Sorghum**	**Wheat**	**Sorghum**	**Wheat**
Multigrain *roti*	146 ±8.16	138±6.28	68±3.78	64 ±2.95	28 ±1.06*	32 ±1.46*
Coarse rawa *upma*	114±1.93*	125 ±4.65*	53±0.90*	58 ±2.13*	23±1.25**	27±0.99**
Fine Rawa U*pma*	119±7.04**	144 ±8.77**	56±3.29**	67 ±4.03**	26±4.62**	46±2.77**
Flakes Poha+	96 ±4.28**	158 ±8.17**	45±1.97**	74 ±3.81**	52±7.01**	90±2.17**
Pasta	100±3.58**	154 ±3.71**	46±1.63**	72± 1.78**	60±6.99**	74±3.83**
Biscuits	115± 4.39	122 ± 4.42	54±2.04	57 ±2.09	23±2.85**	31±1.11**

*(Results are Mean ±SE; * Significant at 5 % level; ** Significant at 1 % level)*

Fig 39 Evaluation of Glycemic Index

Effect of sorghum diet on glycosilated hemoglobin and lipid profile in people suffering from diabetes

Effect of sorghum diet on glycosilated hemoglobin and lipid profile in diabetic patients was assessed with supplementation of sorghum diet for a period of 60 days. Volunteers (n=150) in the age of 30-60 years, suffering from type 2 diabetes were recruited for the study. The study was approved by the Institutional Ethics Committee of the National Institute of Nutrition, Hyderabad. The control group was given diet and experimental group was given 50% sorghum diet and 50 % rice diet for a period of 2 months. The anthropometric indices such as height, weight and BMI were measured and biochemical indices such as glycosilated hemoglobin, fasting blood glucose, hemoglobin, insulin, creatine, triglyceridres, and LDL and HDL cholesterol were assessed before and after supplementation of sorghum diet using standard methods. The biochemical indices showed that there was a significant decrease in glycosilated hemoglobin, fasting glucose and an increase in hemoglobin (table. 56).

Table 56: Mean glycosilated hemoglobin and lipid profile of diabetic patients before and after supplementation of sorghum

Parameter	Before	After
Glycosilated Hb (g %) (Normal - <7.0)	7.9 ± 2.0*	7.3 ± 1.5*
Fasting glucose (mg%)	161.3 ± 50.35*	150.4 ± 54.16*
Hemoglobin (g%)	15.3 ± 4.80*	13.1 ± 2.19*
Insulin (µ/ml)	24.9 ± 16.54	24.6 ± 18.2
Creatine (mg %)	1.02 ± 0.21	1.0 ± 0.19
Cholesterol (mg %)	189 ± 47.15	190 ± 33.78
HDL Chol. (mg %)	54.3 ± 13.38	54.9 ± 16.01
Triglycerides (mg %)	139.2 ± 73.75	138.0 ± 74.92

*(Results are Mean ±SD; * Significant at 5 % level)*

Effect of sorghum diet on nutritional status of school going children

To assess the effect of sorghum diet on nutritional status of school going children, girls (n=137) and boys (n=125), age between 9-12 years , residing at Wanaparthy hostel , Mahabubnagar (D.t), Andhra Pradesh were recruited for the study. The study was approved by the Institutional Ethics Committee of the National Institute of Nutrition, Hyderabad. School going children were divided into control and experimental groups. The control group was given regular rice diet and experimental group was given 50% sorghum diet and 50 % rice diet for a period of 8 months. The anthropometric indices such as height, weight and BMI were measured and biochemical indices such as hemoglobin, total protein, albumin, ferritin, foilc acid, vitamin B-12, iron and calcium were assessed before and after supplementation of sorghum diet using standard methods. The biochemical indices showed that there was a significant increase in hemoglobin, serum total protein, albumin, ferritin, foilc acid, vitamin B-12, iron and calcium levels with the supplementation of sorghum diet (table.57).

Table 57: Nutritional status of school going children before and after sorghum supplementation

Group	Intervention	BMI (kg/m^2)	Hb (g/dl)	Total Protein (g/dl)	Ferritin (ng/ml)	Folic acid (ng/ml)	Vitamin B_{12} (ng/ml)
Experimental	Before	15.1± 1.2	11.0 ± 2.10	9.2 ± 0.82*	34.9 ± 26.01	4.6± 1.75	295.0± 44.93
Control		15.2± 1.37	12.0± 1.49*	9.4± 1.27 *	53.5± 26.67*	4.6 ± 1.78	216.5± 35.60*
Experimental	After	15.0± 1.81	12.4± 1.54*	8.5± 0.61	63.2± 49.92*	5.2± 1.94*	375.0± 176.70*
Control		15.5± 1.26	11.4 ± 1.86	8.8± 0.67	40.2 ± 16.86	5.3± 2.03§	261.9 ± 163.93

*(Results are Mean ±SD; * Significant at 5 % level)*

Fig 39: Evaluation of sorghum diet on nutritional status of children

Amino acid profile of sorghum foods

Sorghum multi grain flour has better availability of total proteins and the individual amino acids especially the methionine, an essential amino acid, in twice the levels than in sorghum flour. The total amino acids present in all sorghum foods were almost similar. However, the total essential amino acids were higher in sorghum flour than other foods and amino acid score was higher in multigrain flour (table 58&59). This could be due to inclusion of soybean in the flour. In all the sorghum based products as in most cereal based products, the amino acid lysine is the limiting factor and is the cause of poor quality protein. This can be overcome by inclusion of lentils and legumes in the sorghum diet.

Table 58: Amino acid profile (g/100 g of protein) of sorghum foods

Amino acid (g/100g of protein)	Sorghum Flour	Sorghum -Soya blend Flour	Sorghum Rawa	Sorghum Pasta	Sorghum Flakes	Sorghum Biscuits
Aspartic	7.11	6.75	6.51	5.62	6.32	7.04
Threonine	3.32	3.11	3.08	3.00	3.17	3.65
Serine	4.95	3.41	4.82	5.06	4.86	4.04
Glutamic acid	23.7	27.7	25.10	31.5	24.8	23.2
Proline	3.06	5.15	3.36	3.07	3.64	3.82
Glycine	3.3	4.27	2.69	3.33	2.89	4.42
Alanine	10.87	5.87	11.13	7.84	11.36	9.36
Cysteine	0.56	0.69	0.60	0.61	0.48	0.78
Valine	5.35	5.67	5.25	5.13	5.44	6.28
Methionine	0.55	0.96	0.59	0.60	0.60	0.63
Isoleucine	3.72	4.02	3.83	3.76	3.88	4.48
Leucine	14.24	9.32	14.97	12.01	14.6	13.18
Tryosine	4.37	3.68	4.52	4.13	4.00	4.38
Phenylanine	5.53	5.34	5.7	5.55	5.64	5.56
Histidine	2.26	2.6	9.19	2.26	2.22	2.44
Lysine	2.48	3.58	1.89	2.03	2.03	2.42
Arginine	4.26	5.27	3.57	3.95	3.68	3.75

Table 59: Total Amino acids, Amino acid score, Total essential amino acids and limiting amino acids of sorghum foods

Nutrient (g/100g of protein)	Sorghum Flour	Multigrain Flour	Sorghum Rawa	Sorghum Pasta	Sorghum Flakes	Sorghum Biscuits
Total amino acid	99.65	97.40	99.81	99.42	99.60	98.44
Total essential amino acids	40.12	36.38	40.43	36.83	39.84	41.35
Amino acid score	42.74	61.71	32.64	35.09	34.97	41.75
Limiting amino acid	lysine	lysine	lysine	lysine	lysine	lysine

Determination of protein efficiency of sorghum

Six Weanling male NIN – Wistar rats of similar weight were taken in three groups to assess the protein efficiency of sorghum. Animal Ethics committee approval was obtained, P20/7-2011/GBR to conduct the study. One group fed with control – casein starch diet, the second group received sorghum diet and the third group protein free diet for two weeks. The total amount diet intake and feces excreted were measured during the last 4 days of experiment. The feces were lyophilized weighed and ground to measure the protein digestibility of sorghum. The following formula was used to calculate the true protein digestibility.

True protein Digestibility =PI-[FP – MFP] /PI x 100
Where PI = Protein Intake, FP = Fecal Protein, MFP = Metabolic fecal Protein

True protein digestibility of casein starch diet = 96.7
True digestibility of sorghum = 89.9
Amino acid score of casein = 93
Amino acid score of sorghum = 42.74
PDCAAS of casein starch diet = 89.9%
PDCAAS of sorghum diet = 38.4%

This PDCAAS value was compared with that the reported literature and found the values were far superior to the reported literature.

Table 60: AAS and PDCAAS values for sorghum calculated using the 2002 WHO/FAO/UNU Expert Consultation recommendation

Age group reference	Lysine scoring pattern	AAS	Threonine scoring pattern	AAS	Tryptophan scoring pattern	AAS	PDCAAS (based on lysine)
0-5 years	57	0.35	31	1.00	8.5	1.29	0.26
1-2 years	52	0.38	27	1.15	7.4	1.49	0.28
4-18 years	48	0.42	25	1.24	6.5	1.69	0.31
>18 years	45	0.44	23	1.35	6.0	1.83	0.33

Source: Advances in Food and Nutrition Research, Vol 60, 2010

Fig 40: Assessment of protein efficiency of sorghum in weanling male NIN – Wistar rats

F. Entrepreneurship Development (DSR & ITC)

Entrepreneurship development training on improved methods of cultivation vis-à-vis marketing their produce led to increase in Sorghum farmers' income as well as Sorghum production. Entrepreneurship Development programmes are jointly organized by ITC and DSR and specialists from various institutes like DSR, ITC and College of Home Science, MAU participated as resource persons on sorghum cultivation, processing, and marketing of Jowar based products. The farmers' participation was overwhelming as they proactively learned on innovative Jowar processing technologies. In this programme women enthusiastically participated and evinced interested on recipes of Jowar Laddu and Jowar Idly. Further, the sorghum flakes preparation was demonstrated to the participants, using flaking machine Jowar products are displayed in the stall. In this programme nearly 600 farmers including rural women and entrepreneurs were trained at Borisawant choupal on the premises of Sorghum mini processing plant.

Machineries of standardized Sorghum products were demonstrated to about 2000 rural entrepreneurs, farmers and women self groups at ITC Choupal Sagar in Parbhani. 1000 rural women are trained on development in Sorghum food processing, 60 farm women/ SHG members were imparted training on Sorghum processing at Adilabad & Parbhani and Nalgonda & Jadcherla districts respectively. Sorghum flake production was demonstrated and trained to nearly 600 farmers including rural women and entrepreneurs at Borisawant choupal. Roti making machine showcased in the Media Meet organized by DIAP at NAARM in 2009. In fact we have organized more than 30 Entrepreneurship Development programmes for farmers, rural women and SHG's who are actively pursuing for financial support from Banking institutions to establish flaking and other processing units. This provides employment during their off season, higher income from their produce and above all, positive impact in their overall farm practices which evidently renewed the mindset of participating Sorghum farmers from subsistent farming to commercial farming.

G. Entrepreneurship development at farm level

The value-added processing technologies that are either developed/fine-tuned are disseminated through rural entrepreneurship programs to the various farmers groups, rural women and NGOs in targeted district of Parbhani, Maharashtra, especially among the participating farmers under the intensive *rabi* sorghum end-product specific on farm production during the past two years through the successful model of ITC (ABD)'s E-choupal.

The Processing and Entrepreneurship development programs are simultaneously conducted in the target area and at the DSR, Hyderabad. The below table reveals that altogether Rs 18,33,342 is spend for the 1000 farmers so far in 8 seasons, which comes to Rs. 229 per farmer per season.

Table 61: Expenditure incurred for the Entrepreneurship trainings and related services (Average for four seasons (4 each of kharif & rabi)

Sl. No.	Particulars	Amount (Rs)	Percent share
a)	Training	**7,01,150**	38
b)	Literature & Creating awareness	**10,09,062**	55
e)	*Choupal haat* program	**1,23,490**	7
	Total Expenditure (A)	**18,33,342**	**100**
B	**Factorization of expenditure per farmer (A/1000)**	**1,833.34**	
	Factorization of expenditure per farmer per season (B/8).	**229.17**	

The salient features of entrepreneurship development programs that have been undertaken under the MVC sub-project are given below:

- **Field Day:** Field days have been conducted during off season in the Project area. It is conducted before the sowing starts, wherein participating farmers are imparted about the improved methods of cultivation and about the various developments that have been taking place about the sorghum products through technological development. Moreover farmers are interacted and discussed about the roles both parties should play in the integrated value chain of sorghum.
- **Literature & Creating awareness:** sorghum recipes books and recommended package of practices for rabi/kharif sorghum cultivation in local dialect/language is distributed among the farmers. Video film on *roti* making in sorghum & package of practices (POP) of sorghum cultivation in 4 languages are prepared and CDs were distributed to the farmers. TV Shows , News and Print media coverage Programme have been telecasted in popular local Telugu channels in Andhra Pradesh such as TV 5 , Sakshi TV, Gemini T V,HM TV,ETV-2 and had published 6 Articles in News papers.
- **Processing training:** The farmers are exposed to various sorghum processing technology and given the privilege to learn them practically at the Processing Laboratory at DSR, Hyderabad.

- **Choupal haat program:** 12 *Choupal haat* programmes had been conducted in Parbhani and Nanded districts. In this, a stall is set up in one of the rural market of the target area wherein various sorghum processed and semi-processed products that are developed at the DSR Processing Laboratory are exposed while literature of those products are distributed to the farmers. This is one effective way of interacting and motivating the farmers to put more input in sorghum for more profit and higher income.

H. Entrepreneurship Development programmes at DSR

The ultimate goal of entrepreneurship development programmes is to disseminate thorough knowledge of post-harvest management which includes linkage of farmers with market, processing, nutritional importance of sorghum, and marketing. Under the below given topics the stakeholders were trained who includes progressive farmers, rural entrepreneurs, NGOs, SHGs, small and medium scale processors, women group entrepreneurs.

- **Value chain experience in sorghum/millets cultivation:** under this topic, the trainees were taught on the intensive sorghum cultivation through public private partnership mode in which sorghum cultivation was introduced and given orientation as commercial proposition that changes the mind-set of the participating farmers. The technological backstopping of the participating farmers with improved cultivars and buy-back facilitation, and the value addition at farm level. All this experiences were disseminated in such a way that it can be replicated in context of other millets too.
- **Nutritional importance of sorghum**: highlights the protein-calorie malnutrition and also over nutrition among the populace of the country and how the various diseases that have been prevailing can be prevented by consuming sorghum. The nutritional values of sorghum and the comparative result of sorghum consumer and non -sorghum consumers (NIN findings based on clinical trials data) disseminated to the trainees. The superiority of sorghum over other cereals such as rice and wheat in terms of nutrition, minerals and vitamins are discussed, the advantage of sorghum's low glycemic index and glycemic load, its gluten free character and rich fibre contains are thoroughly discussed to get clear understanding of sorghum nutritional superiority over food products based on rice and wheat.
- **Post Harvest Technologies of Sorghum/ Millets:** entire scope of processing and enhancing the values of farmers produce at optimum intervention. Processing interventions in sorghum led to removal of inconveniences in preparation of traditional rotis and offers health conscious urban consumers a wide range of choice of healthy and convenient RTC/E (ready to cook/eat) foods. Food technologies especially in instant foods segment there is big scope for small scale processors, for those who can invest small capital.

- **Branding, Packaging and labelling**: Capacity building on relatively a new subject which is very crucial for commercialization process in today's context is dealt with for the benefit of entrepreneurs. This would help them to know how and what regarding introducing their own brand, and the advantage of innovative packaging and labelling. The most common question that arises is whether it is possible to begin commercialising in their own brand; accordingly we give them the guidelines, financial flexibility (capital requirement). Economic feasibility plans are drawn and business plans formats are worked out for ED.

Since farmers are considered key stakeholder, top priority is given at farm level. Orientation on improved methods of sorghum cultivation has been given to around 4000 farmers in partnership with ITC (ABD) Ltd. Also conducting Choupal Haat wherein DSR product technologies are displayed and technologies are demonstrated to the farmers that covers more number to around 15000 farmers, which is in fact the best way to educate the farmers on entrepreneurship development.

I. **Market Research**

In order to develop the market demand for value added Jowar Foods, ITC-ABD has undertaken a study on "Value chain analysis for Identification of Millet foods with Market Potential". The study objectives involved commodity profiling of Sorghum and Bajra, value chain analysis at commodity level and value addition by way of processing into on-shelf products, identify the value added products and assess market potential in select Urban and Rural markets. Subsequently five food products ie Multi grain Atta, Jowar Rich Biscuits, Jowar Vermicelli in Branded segment and Jowar Suji and Jowar Flakes/ Poha in Unbranded segment have been identified for the launch in Mass and Niche markets to the consumers. A market research study on consumer insights to provide inputs for devising marketing strategy for commercialization of the identified Sorghum food products was undertaken in 2011. The study is titled "Market research and Strategy on Jowar Food Products – Consumer acceptance, profiling, segmentation, positioning and communication strategy". The insights gathered from this market research helped the entrepreneurs associated with the project in commercialization of Jowar food products specific to markets / consumers needs.

J. Market, Social and Policy perspectives

Strong traditional habits and preference of these millets as staples in daily dietary requirements resulted in larger retention of grain at farm level for the same thereby impacting both marketable and marketed surplus in the production tracks. In order to increase the consumption of Sorghum processed foods (semolina, vermicelli, pasta, flakes, baked foods, etc) we need to bring attention among people. Existing niche markets such as gluten-free products includes *atta* and cookies, etc., which has market potential both in domestic and exported markets.

The prices of Eatrite Jowar products are, in general on par or less with existing alternative cereal products available in the market. Jowar products are promoted as health beneficial

products with a tag of superior nutritional profile over the existing maida/ rice/ maize based products.

Recent consumer study concluded that all age groups of consumers like Sorghum products highly and seek for their availability in nearby stores in Hyderabad, Pune and Delhi cities.

The importance of millets have been spoken of in popular TV channels besides giving presentations at important national seminars and conferences such as AERA and AMA conference and so on besides NAIP and ICAR meetings. Subsequently, national brainstorming on millets was also held wherein MVC sub-project was recognized as the ideal model for the sustenance of millets and millet farmers. The success story of millets value chain in PPP mode has captured the attention of the high profile scientists and agricultural policy makers of the country. The policy makers are sensitized about the importance of sorghum and other millets for potentiality of uplifting the living standards of dry-land farmers.

Consumer acceptability

In order to find out the consumer acceptability, feasibility and sustainability of newly developed sorghum RTE and RTC products under the DSR brand name 'Eatrite' in the market, the study was conducted in traditional sorghum consuming city of Hyderabad and Pune, and non-traditional Delhi during 2012. And the report is documented and published entitling "Market research and Strategy on Jowar food products: Consumer acceptance, profiling, segmentation, positioning and communication strategies"

The feedback of the consumers on various factors such as packaging, product attributes before and after cooking, experience encountered while preparation and consumption were captured through a structured questionnaire. The consumers provided their acceptability rating on the product attributes including packaging, appearance, color, smell, texture, preparation process, taste etc., in both raw as well cooked forms using 5-point hedonic scale (5=Liked very much, 4=Liked moderately, 3=Neither liked or nor disliked, 2=Disliked moderately and 1=Disliked very much). Consumers rated information on prior awareness of Jowar and its benefits and purchase or not to purchase decision on binary (yes/no) scale.

The willingness to purchase sorghum products in the targeted cities as per the survey report is given below:

- Sorghum Multigrain Atta: 90 percent
- Sorghum Vermicelli: 85 percent
- Sorghum Rich Biscuits: 93 percent
- Sorghum Rawa/ Suji: 80 percent
- Sorghum Flakes: 77 percent

Hyderabad respondents exceed 90 percent, Pune at near margin whereas in Delhi the willingness to purchase sorghum products range at 70 to 80 percent except in case of Multigrain atta it reached 92%.

Determining factors: Taste, Texture, preparation process, appearance, Swelling attribute, color etc. were found to be the driving factors for willingness to purchase of sorghum products

Techno-economic feasibility of sorghum products

The techno-economic feasibility of sorghum-processed products was conducted viz., Jowar rich multigrain atta, Jowar rawa, Jowar vermicelli, Jowar pasta, Jowar biscuits, Jowar flakes. The result shows feasibility and profitability of sorghum processing with respect to cost incurred and market demand. Consequently, commercialization of these products has been initiated by the DSR in partnership with private players.

As a whole sorghum processing of all the products are found profitable and feasible for producing them even at large scale. However, if the machineries are upscaled all the products would have different impact and result which we have planned to worked out through contract millers under DSR-Britannia project. The following table depicts the summary of few parameters on which all the products are evaluated.

Table 62: Techno-economic Feasibility of Sorghum Products

	Product	Cost of the project	Capacity (ton/annum)	Capacity utilization (%)	PAT (lakh)	DSCR	BEP Sales (Rs.)	ROI (%)
1	**Multi grain atta**	62000	240	50	2.00	2.4	120000	106
2	**Jowar rava**	32000	240	50	1.13	3.33	248852	18.62
3	**Jowar Biscuits**	215000	50	50	2.4	4.03	263758	87
4	**Jowar Vermicelli**	825000	24	60	0.6	2.5	411428	29
5	**Jowar pasta**	900000	24	50	3.16	5.27	235640	68
6	**Jowar flakes**	940000	360	50	1.52	3.69	1050000	39

PAT (Profit after tax): after deducting interest @12%, depreciation @10 for Building and 15% for Machineries, and tax @20%

DSCR (Debt coverage ratio): Cash inflow (i.e., PAT+ Depreciation)/Repayment of term loan

BEP Sales (Break-even point): Total variable cost * (Sales-Total variable cost)/Sales
ROI (Return on investment): Earning before tax/Total assets

Findings from above analysis

1. The return over investment is high for multigrain atta followed by jowar biscuits and pasta. The jowar rava due to low recovery the ROI is quite low. The value addition of the byproducts would enhance its RoI.
2. Currently all these machines are operated either at 50% or below capacity utilization except vermicelli production. As you increase capacity utilization its economics will better its performance.
3. The Break even Profit sales point is attained at a low of Rs 1.2 lakhs in case of multigrain as the investment is also low while farthest is for flakes when BEP sales
4. Attained at Rs 10.5 lakhs where the initial capital of Rs 9.40 lakhs invested.

As per the study report, the contributing factors that could increase the scope of sorghum products in the market are briefly given below:

- Increasing number of diabetic patients (IMRD (Institute for Medical Research and Development) research studies indicating that by 2025, the patients in India are likely to surge from existing 3.5 crore to 5.2 crore)
- High incidence of obesity on the back of altering food habits
- High prevalence of arthritis
- Initially, among the given products, Multigrain atta, rava and flakes can be encouraged as these products find daily usage as an input for various other preparations across different sections of the society. Hence these products have ready market which does not require much advertising and promotion to reach the consumers. Besides, Atta and rava can be made with minimum capital inputs hence small and tiny entrepreneurs can be encouraged for making these products with some support from the government.
- The entrepreneurship encouragement can be launched initially in the traditional jowar growing regions viz., Maharashtra and Karnataka later depending on the success and feedback can be extended to various other regions of the country.

Promotional cum Nutritional awareness campaign: (DSR, NIN, ITC & ANGRAU)

Sorghum as nutritional product is found to be most effective in promoting by increasing the awareness on its nutritional benefits. Branding is necessary since Sorghum is generally regarded as poor man's food. For this reason, DSR launched its own brand as "Eatrite" and the products are popularized as healthy foods. The Sorghum products are fine-tuned and standardized now labeled and branded as health foods based on nutritive value established by NIN studies, targeting separately for urban up marketing (middle and higher income classes) and rural markets.

Fig 41: Free Health & Nutritional Counseling

Fig 42: Exhibition at FICCI International Workshop

Fig 43: International Trade Fair, Delhi 2013 with DG, ICAR

Sorghum products were promoted and commercialized at 360 degree communication with BTL & ATL activities. Jowar products were popularized with wet sampling in popularization programmes which included Road shows, exhibitions. And also these products were marketed by Government agencies, wholesalers and retailers and also advertised through Local and National Broadcasting electronic media, News print which included Business line, business standard, etc. For promotion of Eatrite products nutritionists/ doctors/ dieticians were sensitized by DSR and for commercial portal DSR launched www.ieatrite.in website.

Awareness was created on nutritional aspects and popularization of millet recipes to rural as well as urban niche consumers through exhibitions and demonstration of millet food recipes in ITC Choupal Fresh stores, Road shows in public parks, Universities and Malls of Hyderabad and Secunderabad.

Commercialization of the product technologies (DSR)

DSR led consortium developed and standardized more than 25 sorghum products which are aimed at removing inconveniences associated with its preparation and reviving demand for these traditional cereals. However, based on assessment of market potential, consumer acceptability and their convenience aspects it shortlisted them to nine products. The products are labeled and packed in specially designed packets through professional agencies with nutritional profile and other mandated information scribed on it.

Salient features of commercialization and scaling up

- ‘Eatrite’ brand name was registered and launched by DSR with unique selling proposition ‘Eat Jowar Stay Healthy’ for commercialization of sorghum product technologies developed under NAIP- Millets Value Chain
- Successfully commercialized ***Eatrite*** **products** on pilot scale in Hyderabad through Heritage Retail Stores across the city and through unorganised retail sector.
- For sustainability, DSR has Signed MoU with 17 prospective entrepreneurs from Hyderabad, New Delhi and Bangalore with variable emphasis on production, promotion and marketing sorghum product technologies
- An MoU is signed with M/s Britannia, an MNC (first time in the history of ICAR) by DSR to work jointly on R&D on bakery and biscuit products
- The commercialization is solidly backed with the popularization measures adopting various communication strategies
- Horizontal expansion is envisaged in Bangalore, Chennai, Pune and Delhi

DSR has registered a brand name “eatrite” with a tag line ‘Eat Jowar –stay healthy’. The package also gives information on a recipe that can be made from the product. These convenient and

healthy products are targeted primarily at urban population. The products are aggressively promoted through road-shows, nutritional campaigns, print and electronic media across the Hyderabad City on a pilot scale. Currently they are marketed by M/s Heritage Fresh retail chain stores and are explored for their market in unorganized market. The response has been very good and there is an increasing demand for their availability across the city and other major metros. Particularly, multigrain *atta*, pure *jowar* biscuits, flakes have good demand across all age groups.

DSR has signed MoUs with private entrepreneurs so as to make these products available on-shelf across Hyderabad. These products are tested for their nutrient profile and nutritional suitability by National Institute of Nutrition (NIN), Hyderabad and ascertained that they are recommended for those who are ailing from life style disorders such as diabetes and obesity, and are beneficial to all age groups.

Initially we started with aggressive promotion such as organizing Road shows and health awareness campaigns in public parks, malls, etc., wherein the product technologies were displayed and samples are distributed. Later with the increase in awareness by the denizens in Hyderabad, mass media started approaching DSR, which further spreaded its popularity. With the introduction of DSR brand *EATRITE,* with the message 'Eat Jowar, Stay Healthy' it has gain a great momentum from consumers especially in urban areas where people have started looking for health foods. The impact of popularization and increase of awareness among the masses stimulated entrepreneurs who started approaching DSR for either exclusive marketing or manufacturing and marketing the product technologies in their own brand.

"Eatrite" is a brand promoted by the Directorate of Sorghum Research, in India. This brand has been initiated under the National Agricultural Innovation Project (NAIP). The range of products under this brand includes: Sorghum Rich Multigrain Flour, Sorghum Semolina, Sorghum Pasta, Sorghum Vermicelli, Sorghum Flakes& Sorghum Roasted Flakes, and Sorghum Biscuits/Cookies. Under this, 5 formats of business plans are commercialized for Jowar products based on their relative merit assessed in terms of farmer's share in the consumer rupee.

Eatrite products are now marketed through Heritage Fresh and ITC retail chain stores in Hyderabad. Simultaneously, outsourced event managers for popularization of sorghum products (360 degree communication, brand designing logo, etc with BTL and ATL strategies implemented) in urban markets & New age Media. Massive awareness is created on sorghum as health and nutria food through Road shows (100+) in public parks, malls, and institutes *etc* in Hyderabad and in exhibitions by imparting awareness of sorghum to across 40000 consumers through fabricated *Jowar Rath* in Pune, Bangalore, Jabalpur, Chennai, Coimbatore, New Delhi etc. This whole commercialization started with the soft launching of DSR brand *'Eatrite'* at ICAR Krishi Bhavan and other 2 NAFED Outlets in New Delhi.

DSR has also signed Memorandum of Understanding with 15 entrepreneurs of which MoU with multinational Britannia industries Ltd is the most prominent achievement. Others ToR include adopting processing technologies (Cold extruded) at pilot scale for commercialization (M/s GUV Foods), technology licensing on multigrain atta and biscuits (M/s Hope Blessing Enterprise Ltd, Delhi) and taking up Eatrite products for commercialization (remaining 5 firms). DSR has also signed MoU with multi-national M/s Britannia Industries Ltd, Bangalore (first time MoU with

govt. research Institution) for joint research to developed Sorghum biscuits and bakery products of international standards. Many more are in pipeline from cities like Delhi, Bangalore and Chennai. DSR has signed an MoU with M/s Hope Blessing Enterprises ltd, New Delhi to process and market these healthy jowar foods to consumers in Delhi and National Capital Region (NCR).

Policy Sensitizing (DSR)

The success story of millets value chain in PPP mode has captured the attention of high profile scientists and agricultural policy makers of the country. The importance of millets have been spoken of in popular TV channels besides giving presentations during important national seminars and conferences such as AERA conference, AMA conference and so on besides NAIP and ICAR meetings. Created awareness through participation in several exhibitions both national and international and setting up Eatrite Sales counters at NAFED outlets, Krishi Bhavan, NASC Complex, New Delhi.

Fig 44: National Seminar on Millets (Left); Brainstorming Session (Right)

In order to draw the attention of the policy makers with regard to millets, the DSR in collaboration with DMD, Jaipur and NIRD, Hyderabad conducted a National Seminar on Millets in November, 2010. The seminar was ultimately followed by Brainstorming Session in which a task force on millets promotion was set up. Consequently, Initiative for Nutritional and Food Security through Intensive Millets Promotion (INSIMP) project, a Rs. 300 crore under RKVK was launched by DAC with DSR as the Center of Excellence for disseminating processing technologies to around 200 processing clusters that were set up under the scheme across the country. The Centre of Excellence (CoE) at DSR is now in full swing disseminating the technologies developed under NAIP to people from across the country.

Three pilot Mid Day Meal scheme studies with inclusion of millets diet are initiated in 3 states of Maharashtra, Karnataka and AP by the DAC under technical guidance of DSR and Government is actively contemplating mainstreaming millets in public funded welfare programmes targeted various groups.

Summary of benefits

Benefits to stakeholders in the value chain

The stakeholders of the value chain includes sorghum farmers, NGOs, women groups and other farmers' groups, entrepreneurs, research institutes, policy makers and consumers. The dry-land farmers get higher returns from sorghum as a result of the increase in price of their sorghum grain. The farmers groups and NGOs got the advantage of self employment as well as generating employments. The research institutes have coordinated well in their studies as a result of positive impact of the on-farm cultivation from the farmers, while the entrepreneurs get consistent supply of raw material at the most convenient price, desired quality and quantity of grain as a result of bulking of farmers produce by the ITC (ABD) Ltd. The consumers are satisfied with the sorghum products as they have been standardized according to nutritional studies and

consumers' acceptability studies. The policy makers are sensitized of the importance of sorghum and other millets of their potential to uplift the living standards of dry-land farmers.

Benefits to the Sorghum farmers

So far, the progress of the sub-project has shown increase in the farmers' yield and income. Increase in their yield as a result of technological backstopping through product specific improved cultivars, at the same time increase in income with the increase in price of their produce which is a result of directly linking farmers with the market.

Benefits to Entrepreneurs

As mentioned earlier, the product specific technological backstopping vis-à-vis aggregating and bulking of market surplus of the farmers through PPP mode of cultivation provided desired quality and quantity at a convenient price to the small scale processors and manufacturers. Under the MVC sub-project, the recently launched *'eatrite'* brand of DSR vis-à-vis labeling of nutrients that are certified by NIN added more value and attraction to their marketing.

Under various business models Entrepreneurs were provided technology backing through transfer of technology on sorghum products and now most of them produce on their own and market them. Some market eatrite products.

Benefits to financial institutions

There is no specific account of groups that have taken loan from the financial institutions under the MVC sub-project; however, financial institutions especially State Bank of Hyderabad and State Bank of India have a close relation with the farmers in the project area. Obviously, the participating farmers have started forming groups for starting small scale processing through the assistance of ITC and DSR for the formal approach. In this regard, the DSR has made reliable cost analysis of each sorghum product and given entrepreneurship training to make the interested farmer groups, women groups and NGOs possible of applying financial credit from the financial institutions. The financial institutions too are expected to earn huge profits as sorghum products are getting well known by the consumers in the market.

Environmental and social safeguards and their benefits

The environmental and social benefits expected from the sub-project are summarized below.

Status of Environmental & Social Safeguard Framework:

a. As a part of Environmental safeguard under NAIP intervention some benefits were given such as clean sorghum were made available to the customers

b. Reduction in drudgery to women by processing of Sorghum.

c. Provision of nutritious diet to the School children through Mid-day meals under this project.

d. By defining Fair average quality to the farmers adulteration of grain has totally eradicated.

Impact of the sub-project at the macro and micro levels

The sub-project of millets value chain under the public private partnership model wherein all the stakeholders are involved in adding value to the sorghum is expected to uplift the economic standard of the sorghum farmers in the target regions owing to direct linkage with the market or taking up small scale processing of their produce, at the same time encourage the surrounding areas to grow more of sorghum and related millets. It also encourages entrepreneurs dealing with food products to include sorghum in their business exclusively or in combination with other millets. At macro level, the PPP test model is seen to be the ideal model of uplifting the dry-land farmers of India which constituted 65% of the farming area in India.

Future projections

With the positive impact of on-farms sorghum cultivation being visible from the past 3 years, more farmers from different regions are planned to be inducted under the on-farm production and buy-back assurance scheme and all the participating farmers are planned to be given entrepreneurship development training to involve themselves in value addition. At processing level, the products will be standardized and certified by NIN after critically examining the products. With the launching of DSR brand 'EATRITE' and already partnered 17 entrepreneurs with whom the DSR has entered into MoUs, the DSR has started building a wide network of sorghum products for marketing by involving government agencies, more entrepreneurs, wholesalers and retailers by making Hyderabad as the main centre and also the main market while also targeting the national capital and later to the different parts of India.

Uniqueness of value chain vis-à-vis NAIP funding

Before implementation of the current sub-project the supply chain was disjointed and unorganized. The farmers were exploited by the middle men and the local traders. The farmers were also not aware of the price of sorghum in the market. Similarly the research institutes worked independently and were not market driven. Consequently, suitable processing grade varieties of millets and technologies remained on the shelves of the research laboratories due to lack of an institutional mechanism. Under the NAIP sub-project on Millets Value Chain, an institutional mechanism was established to form consortium of stakeholders in public-private partnership ensuring a win-win situation for each stakeholder.

Conclusion

The sub-project of millets value chain under the PPP mode where in all the stakeholders are involved in adding value to Sorghum, is expected to uplift the economic standard of the Sorghum farmers in the target regions through intervention in production, processing, marketing and entrepreneurship development areas. The stakeholders who included farmers, entrepreneurs, NGOs, women's groups, consumers and society as a whole, benefited nutritionally and economically. The positive impact of farmers-market linkages in PPP mode has stimulated other farmers in the region to follow similar practices for enhancing their productivity as well as profitability. It also encouraged entrepreneurs dealing with food products to include Sorghum in their business exclusively or in combination with other millets.

In the declined Sorghum consumption scenario, market for Jowar foods as a convenient and nutritionally beneficial foods including multigrain flour, flakes, vermicelli, pasta and biscuit is surprisingly picking up in urban areas.

In this context of increasing demand for Sorghum, value-addition has acquired a great importance which will have a striking impact on socio-economic conditions of dry-land. The efforts of DSR in creating Industrial linkages for development and commercialization of Sorghum products is seeing positive aspects with more entrepreneurs coming forward to tie up in any kind of intervention as per business plans made by the DSR under the NAIP. This PPP test model of NAIP-Millets Value Chain is seen to be the ideal model of uplifting the dry-land farmers of India which in fact constituted 60 percent of the farming area in India. The model is now replicated for all varieties of millets at national level through INSIMP project by the DAC.

6. Innovations

(Describe about the innovations and their impacts, one page each, please be clear about innovation concept and describe only innovation(s) in brief)

i. **Registration of eatrite brand by DSR for** c**ommercialization of sorghum processed products**

"Eatrite" is a brand promoted by the Directorate of Sorghum Research, in India. This brand has been initiated under the National Agricultural Innovation Project (NAIP) which is quite uncommon for an institutional brand promotion is unique.

Eatrite name is chosen to reflect the characteristics of carbohydrates present in sorghum which are complex in nature that are released slowly, regulating hunger which helps naturally not to over eat but eating right quantities. Eating sorghum is also right because it has high fibre, minerals, vitamins and anti oxidants. Eating sorghum is right because it has manifold health benefits which are enlisted earlier in the report.

The range of products under this brand includes: Sorghum Rich Multigrain Flour, Sorghum Semolina, Sorghum Pasta, Sorghum Vermicelli, Sorghum Flakes& Sorghum Roasted Flakes, and Sorghum Biscuits/ Cookies. Under this, 5 formats of business plans are commercialized for Jowar products which evolved under their relative merit assessed in terms of farmer's share in the consumer rupee.

DSR has now signed Memorandum of Understanding with more than 10 entrepreneurs of which, MoU with multinational company Britannia industries Ltd is a most prominent achievement. Others ToR include adopting processing technologies (Cold extruded) at pilot scale for commercialization (M/s GUV Foods), technology licensing on multigrain atta and biscuits (M/s Hope blessing enterprise ltd, Delhi) and , taking up Eatrite products for commercialization (remaining 5 firms).

Branding, labeling with nutritional profile, recipes, mandatory information and packing was unique in sorghum as there were no products available in the market except multigrain atta.

This has huge impact on consumer perception on product diversification and flagging of nutritional superiority. The acceptability among health conscious urban consumers is great so much so the response of entrepreneurs is overwhelming to produce and market this future alternate nutri-cereal and made MoU with DSR and ANGRAU.

ii. Outsourcing of promotional campaigns

Creation of awareness and promotional campaign was a key intervention which has been aggressively pursued innovatively as the commodity in question was considered by general public as poor man's crop and with two ammunitions of convenience and nutritional superiority mass awareness was created and outreached with message of health and nutritional benefits of sorghum and millets Hyderabad and to other parts of the country. Various innovative strategies were implemented under the NAIP on Millets Value Chain.

A Mobile exhibition was fabricated with attractive colors massaging the taste, convenience and health benefits of sorghum and millet foods. This van has house in facilities for mobilize exhibition, training facilities with audio and visual gadgets. It was named as 'Jowar Rath' which served as branded bus which has almost covered every nook and corner of the Hyderabad.

The promotional activities are outsourced through the event managers for popularization of sorghum products (360 degree communication, brand designing logo, etc with BTL and ATL strategies implemented) in urban markets & New age Media. Ieatrite.in portal was created for this purpose. Jingles were made. Massive awareness is created on sorghum as health and nutria food through more than 200 Road shows and wet sampling in public parks, malls, and institutes etc in Hyderabad and in 100s of exhibitions in imparting awareness of sorghum to across 4,00,000 consumers through fabricated Jowar Rath in Pune, Bangalore, Jabalpur, Chennai, Coimbatore, New Delhi etc.

Through Medians, billboards the sorghum eatrite products were made popular to strengthen entrepreneurs who made MoU's with DSR for increasing the sales volumes. Local Road transport buses were stickered. All these campaigning were outsourced.

Thus a professional approach was given to position of various eatrite products with skillfully making in labeling, packaging and branding.

The tag lines such as "eat jowar stay healthy", "health meets taste" and "small grains- a big gain". The labeling also gives nutritional information provided by NIN, mandatory information and on recipe that can be made from the product. These convenient and healthy products are targeted primarily urban population. The products are aggressively promoted through road-shows, nutritional campaigns, print and electronic media across the Hyderabad City on a pilot scale.

Simultaneously the promotional activities undertaken to create awareness on improved package of practices in sorghum cultivation and on various sorghum convenient foods and processing of sorghum to the farmers and to attract the entrepreneurs to initiate processing industry so as to link the farmers to PCS Value chain, a unique initiative of "Choupal Haats" was launched. These Choupal Haats are conducted in villages on a normal Haat day or engineered specifically to attract the farmers and rural women/ consumers. A portable stall with distinct identity of the Canopy is erected in prominent location and specific literature
(Booklets/ pamphlets) on package of practices, Jowar based recipes are distributed. Awareness has been created among approx. 27,000 farmers till date through such 90 Choupal Haats.

Impact: As a result tremendous awareness creation was made among the urban consumers and rural farmers in the project area. Many entrepreneurs were given promotional support for increasing their sales volumes and private sector sensitization

iii. Aggressive Policy sensitization

Ever since independence, millets, especially sorghum and millets had been known for neglected policy front, with regard to input subsidies as well as output incentives including the public distribution system policy which favored rice and wheat. This resulted in decline in sorghum consumption and in turn area and production in the country. However, of late the importance of millets in health and nutritional security has been realized in wake of many surge in lifestyle diseases in the country. This calls for change in food habits and shift towards nutritional millets. This is expected to revive demand of sorghum cultivation for the benefit of dryland sorghum farmers. Under the subproject of NAIP, we tried to sensitize the policy makers on promoting of millets and flagging them as future crops in event of climate change consequences on eco system.

A National Seminar on millets was jointly organized by DSR and DAC in 2010, which was followed by Brainstorming Session in November, 2010 at NIRD, Hyderabad. Secretary agriculture was appreciative of NAIP initiative and the technologies generated in millets. A task force was formed with the CPI as one of the member; as such INSIMP came into being. So when the government of India was willing to take up millets promotion, the DSR was technology ready, which we developed under the NAIP on Millets Value Chain. Finally in 2011-12 a full - fledged millet programme its promotion is launched a initiative of Nutritional security through intensive millets promotion (INSIMP) with an outlay Rs 300 crore project, emphasizing value chain components in the programme. Thus about 400 beneficiary processing clusters across the millet growing states are supplied freely to the entrepreneurs. These clusters are technologically backstopped by DSR/ NAIP.

Earlier, NIN conducted nutritional study of the developed products on diabetic patients and school children, which shows sorghum products are either on par or more nutritious than the counterparts available on shelf in the market. In fact, promoting sorghum and millets as healthy foods gained wide momentum from the consumers, especially the health conscious urban

consumers. This has made it possible to sensitize the line departments of state governments and policy makers of the country.

Through various workshops, seminars, exhibitions, meetings, millets festivals etc, we tried to rope in Ministry of Agriculture, Child and family welfare, Department of Agriculture and Cooperation, HRD *etc* for mainstreaming millets in public funded programmes.

Line departments of government are sensitized in state governments so that they may also take up millets in public distribution schemes. This has resulted to implementation of millets in Mid-Day Meal programme on the pilot scale by the 3 states of Karnataka, Andhra Pradesh and Maharashtra.

Lastly it is coincidence that Govt of India heeded to include sorghum and millets in PDS.

Impact: DAC funded programme for millets promotion to sustain NAIP efforts in the country. Other Ministries for mainstreaming millets in welfare programmes. A linkage was also established with Private sector giants with DAC to initiate millets promotion by launching some millet based products in their portfolio.

7. Process/ Product/Technology/ Value Chain/ Rural Industry Developed

S. No.	(Process/Product/Technology/ Value Chain/ Rural Industry Developed	Adoption/ Validation/ Commercialization, etc.	Responsible Partner
1.	Sorghum Multigrain atta	Commercialized under Eatrite brand of Directorate of Sorghum Research. DSR has also given license to M/S Bhagyanagar Foods, Hyderabad for production and marketing in their own brand.	DSR
2.	Sorghum Flakes	Commercialized under Eatrite brand of Directorate of Sorghum Research. Established tie up with M/S Bhavani S S Industries, Karnataka for collaborative marketing of roasted flakes.	
3.	Sorghum Rava (3 types. Namely: Idli, Upma and Khichdi rawa)	Commercialized under Eatrite brand of Directorate of Sorghum Research. DSR has issued license to M/S Kottaram Agro Foods Pvt Ltd, Bangalore for production and marketing them in their own brand.	
4.	Sorghum Vermicelli	Commercialized under *Eatrite* brand of Directorate of Sorghum Research. DSR has issued license to M/S GUV Food Products, Hyderabad for producing and marketing sorghum vermicelli in their own brand.	
5.	Sorghum Pasta	Commercialized under *Eatrite* brand of Directorate of Sorghum Research. DSR has issued license to M/S GUV Food Products, Hyderabad for producing and marketing sorghum Pasta in their own brand.	
6.	Sorghum Biscuit	Commercialized under *Eatrite* brand of Directorate of Sorghum Research. Established tie up with M/S Brittania Industries Ltd, Bangalore for R & D of sorghum biscuits, to further	

		commercialized them at national and international level in the days to come.	
7	Ready –to –eat Extruded snack	Commercialized under brand name of ANGRAU as 'ANGRAU Foods'. These products have been licensed to two different entrepreneurs and entered into MoU for up-scaling – Ready to –Cook Gluten free pasta and vermicelli to M/S GUV foods. – Ready-to-Eat extruded foods to M/s Mathesis Engineering Ltd– Food products.	ANGRAU
8	Ready –to-cook Extruded vermicelli		
9	Ready-cook Extruded Pasta		

Note: More details in pro-forma 1,2, & 3.

8. Patents (Filed/Granted)

S. No.	Title of Patent	Inventor(s) (Name & Address)	Filed/Published/ Granted (No./Date)	Responsible Partner
1	Fat free crunchies	ANGRAU Foods	2852/CHE/2012 DATED 13-7-12	ANGRAU

PS: DSR has launched its own brand EATRITE with the tag line 'Eat Jowar Stay Healthy'

9. Linkages and Collaborations

S. No.	Linkages developed (Name & Address of Organization)	Date of MoU/MoA	Responsible Partner
1	DAC, Ministry of Agriculture, Gol, (INSIMP)	Nov., 2010	DSR
2	M/s Heritage Fresh Ltd, Hyderabad	July, 2011	DSR
3	M/s Britannia Industries Pvt. Ltd., Bangalore	11 Nov 2011	DSR
4	M/S Bhagyanagar Foods, Malakpet, Hyderabad	22 Feb., 2010	DSR
5	M/s Vegan Enterprises, Hyderabad	16 June, 2010	DSR
6	M/s GUV Foods, Hyderabad	7 July, 2010	DSR

7	ITC (foods) ltd, Bangalore	2010	DSR
8	M/s Matheses, Hyderabad	2010	DSR
9	M/S Sealed Air Corporation, New Jersey, USA	4 July, 2011	DSR
10	M/s Nova Traders, Hyderabad	5 July, 2011	DSR
11	M/s Kottaram Foods, Bangalore	13 July, 2011	DSR
12	M/s Bhavani S S Industries, Mahal Bagayat, Bijapur, Karnataka	21 July, 2011	DSR
13	M/s Hope Blessing pvt Ltd, Delhi	5 Dec., 2012	DSR
14	M/s Sri Venkateswara enterprises, Hyderabad	2013	DSR
15	M/s Chandu Rotis, Hyderabad	2013	DSR
16	M/s Madhava Kalyan Foods Products, Rajahmundry, AP	17 Sept., 2013	DSR
17	M/s ISA Millets, Hyderabad	20 Nov., 2013	DSR
18	M/s Fountainhead Foods Private Limited, Secunderabad	20 Nov., 2013	DSR

10. Status on Environmental and Social Safeguard Aspects

Environmental			**Social**		
Positive effects	Negative effects	Mitigation measures taken to minimize the negative effects	Positive effects	Negative effects	Mitigation measures taken to minimize the negative effects
Clean sorghum grain for marketing available	-	-	Women's time saved in drudgery of preparation	-	-
Nutritious sorghum diet made available for diabetic and school	-	-	-	Adulteration in supply off grain by farmers	Fair average quality is defined

children					
Safety certification is in place for sorghum foods	-	-	Increased profits from sorghum	-	-
Packaging and Marketing	-	Disposal of package material	-	-	-
-	Grain mold in kharif sorghum	Harvesting at physiological maturity	-	-	-

11. Constraints, if any and Remedial Measures Taken

- Identification of processing grade varieties of millets
- Standardization of production technologies for the selected varieties of millets
- Development of value added products with nutritional, food safety and quality assurance tests,
- Popularization of value added millet products and development of linkages with the market.

12. Publications

A. Research papers in peer reviewed journals

S. No.	Authors, Title of the paper, Name of Journal, Year, Vol. & Page No.	NAAS Ratings	Responsible Partner
1	Development and standardization of sorghum rich multigrain flour and assessment of its storage stability with addition of TBHQ. Journal of food processing preservation	6.5	DSR
2	Rajendra Prasad MP, Dayakar Rao B, Kalpana K and Ratnavathi CV. 2015. Organoleptic Properties and Nutrient Composition of Indian Traditional Snack Recipes Prepared from Sorghum. *International Journal of Family and Home Science*, Volume 11	2.92	NIN & DSR
3	Dayakar Rao B, Patil J.V, Rajendraprasad M.P, Nirmal Reddy K, Kamini Devi, Sriharsha B and Kachui N. 2010. Impact of Innovations in Value Chain on	5.68	DSR, NIN, ITC (ABD) Ltd. &

	Sorghum Farmers. *Agricultural Economics Research Review*. Vol 23: 419-426		ANGRAU
4	Dayakar Rao B. 2010. Linking Sorghum farmers to markets: Issues and approaches. *Agricultural Situation of India.* Vol LXVII (2): 59-68.	-	DSR
5	Dayakar Rao, B., Shashidhar Reddy, Ch., Krishna Rao, E., Mishra, J.S. and Seetharama, N. 2009. Impact of CSH-16 on economics of sorghum cultivation in Ranga Reddy district of Andhra Pradesh. *Agricultural Situation in India.* JP. No. 3/2009-10.	-	DSR
6	Dayakar Rao, B. et al. 2009. Postharvest processing and value -addition of millets for effective marketing. In: *Indian Society of Agricultural Marketing*, Hyderabad. CP No.7/2009-10	-	DSR
7	Dayakar Rao, B., Sashidhar Reddy, Ch., and Seetharama. 2007. "Reorientation of investment in R&D of Millets for food security – the case of Sorghum in India", *Agricultural Situation in India*, Vol. LXIV (No.7), October, Pp 303-305. (IF: 2.0/4.0)	-	DSR

B. Books/ Book chapters/ Abstracts/ Popular articles, Brochures, etc.

S. No.	**Authors, Title of the papers** **Name of Book/ Seminar/ Proceedings/Journal, Publisher, Year, Page No.**	**Responsible Partner**
Books		
1	Dayakar Rao B, Patil J.V, Nirmal Reddy K, Vinay K Soni and Srivatsava G. 2014. Sorghum: An Emerging Cash Crop. Directorate of Sorghum Research, Rajendranagar, Hyderabad, pp 159, published by Cambridge University Press India Pvt. Ltd. ISBN 978-93-82993-52-0	DSR
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16	Dayakar Rao B, Vishala Devender, Kiranmai E, Hymavathy T.V, Sailaja V, Sriharsha B and Mukesh P. 2010. Millet Processing and Value- Addition for Creating Demand. "Research and development in Millets: Present Status and Future Strategies". A book on lead presentations and Abstracts National Seminar on Millets 2010,Directorate of Sorghum Research (DSR), Rajendranagar, Hyderabad-500 030.	DSR & ANGRAU
17	Nirmal Reddy, K.,**Dayakar Rao, B.,** and Sashidhar Reddy, Ch.2010. Poster on "Backward Linkages-Private Sector Participation in Millet production in PCS-Value chain". "Research and Development in Millets:Present status and future strategies" a compilation of lead presentations and abstracts of papers sumitted for National Seminar on Millets, 2010, Directorate of Sorghum Research, Hyderabad Pp no 32. ISBN:81-89335-32-4	ITC & DSR
18	**Dayakar Rao, B**., Patil, J.V., Nirmal Reddy, K.,Ganapathy, K N.,Sriharsha, B.,Kachui,N., and Mukesh, P. 2010. Poster on "Linking of sorghum farmers with Markets in PPP mode". "Research and Development in Millets:Present status and future strategies" a compilation of lead presentations and abstracts of papers sumitted for National Seminar on Millets, 2010, Directorate of Sorghum Research, Hyderabad Pp no 41. ISBN:81-89335-32-4	DSR
19	Hymavathi, T.V.,**Dayakar Rao, B.,** Patil, J.V., Bala Tripura Sundari, Kiranmai, E.,Spandana, S.,and Ratnavathi, C.V., 2010. Poster on "Interventions in millet processing technologies for	ANGRAU & DSR

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20	**Dayakar Rao, B.,**Vishala Devender, Kiranmai, E., Hymavathy, TV ., Sailaja, V., Sriharsha B and Mukesh P., Poster and abstract II-18 Millet Processing and Value- Addition for Creating Demand, (2010) in Research and development in Millets present Status and Future Strategies. A book on lead presentations and Abstracts National Seminar on Millets 2010,Directorate of Sorghum Research (DSR), Rajendranagar, Hyderabad-500 030.	DSR
21	Dayakar Rao, B., Shashidhar Reddy, Ch., Ratnavathi, Krishna Rao, E., Sarada, T., and Seetharama, N., "Approaches for commercialization of sorghum through value-addition and entrepreneurship development". In National seminar on Food security through innovations in food processing and entrepreneurship development, KAU, Vellanikara, Thrissur, 29-30 September 2008.	DSR
22	Rao, S.S., Seetharama, N., Ratnavathi, C.V, Dayakar Rao, B. and Umakanth, A.V. 2008. Utilizing sweet sorghum as an alternative energy crop for bioethanol production: Agrotechnology and pre-commercialization in liaison with agro-industries. Poster (size 3 x 4') presented at the national conference on "Biotechnological Approaches to Alternate Energy" 5-6 Dec, 2008, IITM, Chennai Golden Jubilee Year-2008.	DSR
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2	Dayakar Rao B and Patil JV. 2012. Innovative Agribusiness Opportunities in Millets Value chain & Farm Entrepreneurship Development. *Commodity India* **05** (12): 20-27.	DSR
3	Dayakar Rao B and Patil JV. 2012. A Review on Sorghum suitability for Tackling Urban Lifestyle Diseases. *Commodity India* **07** (12): 22-28.	DSR
4	Dayakar Rao B. 2012. Creation of Demand for Millet Foods	DSR

	through PCS Value Chain. *Food & Beverage News*, 01.10.12.	
5	Dayakar Rao B and Patil JV. 2012. DSR's 6 new Ready-to-eat products lend rural staple Jowar urban appeal. *Food & Beverage News*, 15.09.12.	DSR
6	Dayakar Rao B. 2011. Reviving of Millets promotion in India. *Commodity India*, November 2011	DSR
7	Dayakar Rao B, Nirmal Reddy K and Shashidhar Reddy Ch, N. 2010. Backward Linkages-Private sector participation in Millet production in PCS-Value chain. *Commodity India*, December 2010.	DSR & ITC
8	Dayakar Rao B, Nirmal Reddy K and Shashidhar Reddy Ch, Kachui N. 2010. Backward Linkages- Private sector participation in Millet production in PCS-Value chain. *Commodity India*, December 2010.	DSR
9	Rohit Sidhar, Dayakar Rao, B., Nandita Mathew and Krishna Rao, E. 2009. Analysis of sorghum utilization in India. Jowar Samachar 5(2):9-10.	DSR
10	Dayakar Rao, B., Mishra, JS., and Rao, SS., 2009, "Sorghum production 2007-08, A report of AICSIP coordinating team 2008-09, 39 the AGM 09held at Rajmata Vijayaraje, Scindia Krishi Vishwa Vidyalaya, Indore, 26-28 February, 2009., 65-66 page.	DSR
11	Rao S.S., Seetharama, N., Ratnavathi, C.V., Dayakar Rao, B. and Umakanth, A.V. 2008. Utilizing sweet sorghum as an alternative energy crop for bioethanol production: Agro-technology and pre-commercialization in liaison with agro-industries. Advanced BioTech: VII (05), 46-47.	DSR
12	Dayakar Rao, B. Subbarayudu, B., Sarada, T., Prakash, P. and Seetharama, N. 2008. An analysis on prices of selected rabi cultivars across markets. Jowar Samachar 4(2):4-5 (NRCS 26).	DSR
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1	Shashidhar Reddy, Ch, Mukesh, P, Dayakar Rao, B, and Subbarayudu. B. 2009 "Kharif Jonna digubadiki patincha valasina melukuvalu" Padipantalu (Telugu), August 2009.	DSR
2	Sashidhar Reddy, Ch., Dayakar Rao, B., Mukesh, P. and Subbarayudu, B. 2008. *Kharif Jonna Adhikadiguadiki acharinchaalasina Yajamanyapaddatulu* (In Telugu).	DSR

	Padipantalu 67: 27-29.	
3	Sashidhar Reddy, Ch., Dayakar Rao, B., Mukesh, P. and Subbarayudu, B. 2008. *Jonna pantanu aashinchu purugulu, thegullu vati yajamanyam(*Telugu). Padipantalu 68: 33-35.	DSR
Technical bulletin		
1	Dayakar Rao,B.,2010 "Jowar based semi processed products",Technical bulletin 2009 " NAIP-Millet value chain Project, Directorate of Sorghum Research (DSR), Hyderabad-500 030 2009-2010, March 2010,	DSR
2	Dayakar Rao, B., Shashidhar Reddy, Ch., Nirmal Reddy, K., Naphade, S.A., Baghwath, V.R., Thakrey, U.G. and Seetharama, N. 2009. Kharif Jowariche Sudharith Lagwad Thanthragyan (Marathi). National Agricultural Innovation Project (NAIP), ITC, Secunderabad, 500 003 and DSR, Rajendranagar, 500 030, Andhra Pradesh, India. NAIP/ITC/DSR TECH/11/2009-10, 12 pp.	DSR & ITC
3	Dayakar Rao, B., Shashidhar Reddy, Ch., Nirmal Reddy, K., Shyam Prasad, G. and Seetharama, N., 2009. Package of practices for improved rabi sorghum cultivation (English). National Agricultural Innovation Project (NAIP), ITC, Secunderabad, 500 003 and NRCS, Rajendranagar, 500 030, Andhra Pradesh, India. NAIP/ITC/NRCS TECH/4/2009, 14 pp.	DSR & ITC
4	Dayakar Rao, B., Shashidhar Reddy, Ch., Nirmal Reddy, K. and Seetharama, N. 2008. Package of practices for improved kharif sorghum cultivation (English). National Agricultural Innovation Project (NAIP), ITC, Secunderabad, 500 003 and NRCS, Rajendranagar, 500 030, Andhra Pradesh, India. NAIP/ITC/NRCS TECH/2/2008-09, 16 pp.	DSR & ITC
5	Dayakar Rao, B., Shashidhar Reddy, Ch., Nirmal Reddy, K. and Seetharama, N. 2008. Rabi Jowarichya Sudharit Lagwad Padhati (Marathi). National Agricultural Innovation Project (NAIP), ITC, Secunderabad, 500 003 and NRCS, Rajendranagar, 500 030, Andhra Pradesh, India. NAIP/ITC/NRCS TECH/2/2008-09, 16 pp.	DSR & ITC
6	Shashidhar Reddy, Ch., Dayakar Rao, B., Nirmal Reddy, K. and Seetharama, N. 2008. Kharif Jonna Adhika Dhigubadiki melaina sankethika parignanam (Telugu). National Agricultural Innovation Project (NAIP), ITC, Secunderabad, 500 003 and NRCS, Rajendranagar, 500 030, Andhra Pradesh, India.	DSR & ITC

	NAIP/ITC/NRCS TECH/1/2008-09, 16 pp.	
Press release several-few are given below		
1	Dayakar Rao B and Patil JV. 2012. Sorghum Directorate to partner FMCG majors. *Business Standard.* 25.08.12.	DSR
2	Dayakar Rao B and Patil JV. 2012. Sorghum Directorate to rope in private players for brand push. *Business Standard*. 4.09.12.	DSR
3	Dayakar Rao B, Patil JV and Vishala AD. 2012. Chirudanyam tho Arogya Bhagyam. *Eenadu* (Local Telugu popular daily). 6.11.12.	DSR
4	Hymavathi TV. 2012. Make millets Your friends .*The Hans India*. 02.04.12	ANGRAU
Pamphlets		
1	Dayakar Rao B and Patil J.V. 2012. Product Catalogue on EATRITE Products. Directorate of Sorghum Research, Hyderabad.	DSR
2	Dayakar Rao B, Ratnavathi CV, Nirmal Reddy K, Rajendra Prasad M.P, Kamini Devi and Rao S.V. 2010. NAIP sub-project on Creation of demand for millet foods through PCS value-chain. Directorate of Sorghum Research, Hyderabad	DSR, ITC, NIN & ANGRAU
3	Dayakar Rao B, Ratnavathi C.V, Nirmal Reddy K, Rajendra Prasad M.P, Kamini Devi and Rao S.V. 2010. Reinventing of Sorghum as health and convenient food and Other Value-added uses. Directorate of Sorghum Research, Hyderabad.	DSR, ITC, NIN & ANGRAU
4	Dayakar Rao, B., Ratnavathi, C.V., Shashi Reddy, Ch. and Shyam Prasad, G. 2008. Sorghum for health and business through value-addition. National Agricultural Innovation Project (NAIP) & National Research Centre for Sorghum (NRCS), Rajendranagar, 500 030, Andhra Pradesh, India. Pamphlet 8 -08/08.	DSR
5	Dayakar Rao, B., Ratnavathi, CV., Nirmal Reddy, K., Rajendra Prasad, MP., Kamini Devi., and Seetharama, N., 2008, brochure on "NAIP sub-project on 'Creation of demand for millet foods through PCS value-chain'", NAIP-NRCS, Hyderabad, 44 pp.	DSR
Television Interview		
1	Dayakar Rao, B. 2012. Television Interview on "Value addition and Processing of Sorghum" at Sakshi Television Studio,	DSR

	Hyderabad, 10th June 2012.	
2	Interviews with local TV channels such as TV 5, EETV 2, HMTV etc	DSR
3	Press meet during Inauguration of- CoE by Sri P K Basu on 14-02-2012 at DSR ,Hyderabad	DSR
4	Dayakar Rao, B. 2012. Doordarshan, National coverage interviewed on promotion of health and convenient jowar based products and their on the occasion of 83rd ICAR general body meeting NASC complex.	DSR
5	Dayakar Rao, B. 2011. Entrepreneurship Development program for rural women, SHGs and rural entrepreneurs at Bhogaon Choupal on 16th Sep 2011.	DSR
6	Dayakar Rao, B. 2010. Business standard dated 26 March 2010	DSR
7	Dayakar Rao, B. 2010. Andhra Jyothi dated 20 February 2010.	DSR
8	Dayakar Rao, B. 2010. Deccan Chronicle dated 30 January 2010.	DSR
9	Dayakar Rao, B. 2010. New Indian Express	DSR
10	Dayakar Rao, B. 2010. Participated and Interacted with HMTV for creating awareness on sorghum convenient foods and Nutritional benefits in association with NIN Director.	DSR
11	Dayakar Rao, B. 2010. Interview with TV-5 regarding sorghum processing and processed foods.	DSR
12	Dayakar Rao, B. 2010. Press conference on the occasion of National Seminar on Millets 2010 in November 2010.	DSR
Report		
1	Dayakar Rao, B., Sarada, T., and Krishna Rao, E., 2010, "Cluster profile of Indraveli-Hub end product specific on-farm kharif sorghum cultivation in Adilabad district", report on analysis of on-farm end-product specific kharif production in Adilabad district, NRCS Hyderabad, 40 pp.	DSR
2	Dayakar Rao, B., Sarada, T., and Krishna Rao, E., 2010, "Profile of Rabi sorghum on farm production for end products specificity in Parbhani district", report on analysis of on-farm end-product specific rabi production in Parbhani district, DSR Hyderabad.	DSR
3	Dayakar Rao, B., and Krishna Rao, E., 2010, "Profile of end product specific on-farm kharif sorghum cultivation in Adilabad district", report on analysis of on-farm end-product specific kharif production in Adilabad district, DSR Hyderabad	DSR

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4	Dayakar Rao, B., Nirmal Reddy, K., Krishna Rao, E., and Sarada, T., 2009, "Baseline survey report results on on-farm sorghum production in Parbhani (rabi) and Adilabad (kharif) districts" NRCS – ITC Ltd, NAIP – MVC, New Delhi pp.	DSR
5	Dayakar Rao, B., Sarada, T., and Krishna Rao, E., 2009, "Cluster profile of Indraveli-Hub end product specific on-farm kharif sorghum cultivation in Adilabad district", report on analysis of on-farm end-product specific kharif production in Adilabad district, NRCS Hyderabad, 40 pp.	DSR
6	Dayakar Rao, B., Vimala Devi, Sarada, T., Krishna Rao, E., and Seetharama, N., 2008, "Consumption Pattern of Sorghum and Pearl Millet 2008", report based on baseline survey by Varsha Society, Hyderabad, NAIP – MVC, New Delhi, 116 pp.	DSR
7	Dayakar Rao, B., Shashidhar Reddy, Ch., and Sudershan Rao, BV. 2008, "Impact of CSH-16 hybrid Jowar in terms of yield and net income in selected mandals of Ranga Reddy district of Andhra Pradesh", report for assessment of impact of CSH-16 in Ranga Reddy district, conducted by Varsha Society for NRCS, Hyderabad, 51 pp.	DSR

Media Products Developed/Disseminated

S. No.	CD, Bulletins, Brochures, etc. (Year wise)	No. of Copies	Distribution	Responsible Partner
1	Dayakar Rao,B. and Patil, J.V. 2012. A video film on "Preparation of delicious recipes from Sorghum", Directorate of Sorghum Research, Hyderabad, Andhra Pradesh, India.	1000	1000	DSR
2	Dayakar Rao, B. and Patil, J.V. 2012. A video film on Demonstration of Primary and Secondary processing equipment for Sorghum processing" Directorate of Sorghum Research, Hyderabad 500030, Andhra Pradesh, India.	1000	1000	DSR
3	Dayakar Rao, B. and Patil, J.V. 2012.A video film on "Entrepreneurship	1000	1000	DSR

	Development on Sorghum processing" Directorate of Sorghum Research, Hyderabad, Andhra Pradesh, India.			
4	Video-film on roti making in sorghum & POP in 4 languages.	1000 CDs	1000 CDs	DSR
5	Sorghum recipes Book (English)	5000	1000	DSR
6	Sorghum *Package of Practices (PoP):* -			
	Telugu	2000	2000	DSR
	Marathi	5000	5000	DSR
	Hindi	1000	1000	DSR
	English	1000	1000	DSR
7	DVDs / CDs on Improved package of practices of Sorghum. (Kharif & Rabi)			
	Telugu	250	250	ITC & DSR
	Marathi	250	250	ITC & DSR
	Hindi	250	250	ITC & DSR
	English	250	250	ITC & DSR
8	Booklets on Improved package of practices of Kharif and Sorghum cultivation	8000	Distributed to farmers	ITC & DSR
9	Include millets and ensure health and nutrition - flyers	2000	Distributed during Hariton Feb 2013	ITC & DSR
10	Telugu brochure on "Merugaina arograniki jeevana saiili vyadhula nivaranaku chirudhanyalu" (Millets for promoting health an dpreventing life style diseases) Posters developed 1. Ancient Foods in Modern Form 2. Millets are Gluten – Free 3. Possible Effects of Gluten Sensitivity/ Intolerance	4000	For distribution during exhibitions in rural exhibitions	ITC & DSR

	4. Amazing Millets 5. Go…. Millets 6. Millet Technology Bank 7. Millets for Healthy Life 8. Low Digestible Carbohydrates			

13. Meetings/Seminars/Trainings/Kisan Mela, etc. organized

S. No.	Details of Meetings/Seminars/Trainings, etc.	Duration (From-To)	No. of Personnel Trained	Organizer (Name & Address)
1	Global Consultation on Millets Promotion	3 days during 18-20 Dec 2013	350	DSR
2	5 Entrepreneurship development Trainings	10 days during Feb to March 2013	250	DSR
3	Machineries for bulk preparation of standardized sorghum products were procured by DSR, and demonstrated to rural entrepreneurs, farmers and Women self- help groups at ITC Choupal Sagar in Parbhani.	1 day	1000	DSR & ITC Ltd.
4	Six separate trainings organized *at DSR* on preparation and *operation of* Flaking machine, dehuller, parboiling unit and were installed in a *echoupal* village as demo-units.	6 days	240	DSR
5	Rural women / entrepreneurs are trained on Entrepreneurship development in sorghum food processing in Adilabad and Parbhani districts.	2 days	450	DSR & ITC Ltd.
6	60 farm women / SHG members/small processors were	2 days	60	DSR

	imparted on sorghum processing at Nalgonda and Jadcherla.			
7	SHG women from Chevella and SHG women entrepreneurs from different places were provided training on processing of sorghum and value- addition at DSR.	1 day	55	DSR
8	2 days training programme on Value addition from sorghum for the SHG group members of KVK, Cuddapah, and the self-help group members of KVK, Banaganepalle, AP, India	17- 18 December 2012	80	ANGRAU
9	National workshop on Value chain experiences in Millets with special reference to Sorghum has been organized in association with FAPCCI on 30 May 2011 at Federation house, FAPCCI Hyderabad	1 day	100	DSR
10	Workshop on Market led on-farm Sorghum production to the Parbhani farmers in October 2011	1 day	500	ITC & DSR
11	"Post Harvest Technologies of Sorghum under INSIMP" for Farmers and entrepreneurs from Maharashtra and Andhra Pradesh.	2 day	100	DSR
12	Women Empowerment and Entrepreneurship Development programme in Tadkalas village in Parbhani District in March 2012.	1 day	200	ITC & DSR
13	National workshop on "Value chain experiences on Agricultural commodities Millets & Maize"	30 May 2011	100	DSR & FAPCCI
14	Farmers Training Programme on "Production, utilization and Value-addition in sorghum with special reference to Kharif sorghum at Directorate of Sorghum Research, Hyderabad	28- 29 August, 2011	50	DSR & ITC Ltd.

15	Workshop on Women empowerment and Entrepreneurship Development in Sorghum food processing in Borisawant village in Parbhani district	January 2011	500	ITC & DSR
16	National Seminar on Millets	Nov, 2010	200	DSR, DMD & NIRD
17	Workshop on Intensive Market Led Rabi Sorghum Cultivation & Value Addition Opportunities at Parbhani	October 2010	1000	DSR-ITC (ABD)
18	Kharif sorghum on-farm production orientation programme	6-6-10	750	DSR-ITC (ABD)
19	Six Farmers are trained at DSR food processing lab for sorghum processing.	16-7-10	6	DSR-ITC (ABD)
20	A women-staff of DSR organized training programme to SHGs at Chevella, AP and surrounding villages for promoting sorghum processed foods by demonstration.	20-7-10	60	DSR-ANGRAU
21	Sixteen rural entrepreneurs from Parbhani district are trained in preparation of sorghum Processed foods at DSR Food processing lab.	16-8-10 to 19-8-10	16	DSR- ITC (ABD)
22	Three farmers from Parbhani are trained at DSR for Flaking and processing of sorghum.	3-9-10 to 4-9-10	3	DSR
23	Forty farmers are given training in Sorghum production, consumption and value-addition at DSR in September 2010.	28-9-10 to 30-9-10	40	DSR- ITC (ABD)
24	35 Women farmers are given training on entrepreneurship development and sorghum processing at DSR.	29-09-10	35	DSR- ITC (ABD)
25	Demonstration was given on the	25-11-10	50	ANGRAU-

	value addition from sorghum products at A.V.College, Hyderabad			DSR
26	Conducted 2 days training programme on value addition from sorghum for the SHG group members of Jammikunta (KVK, Karimnagar dist) and SHG group members of NGO, IPWWA at Jadcherla, Mahabub nagar, Hyderabad	December 27-28,2010	10	ANGRAU
27	Women Entrepreneurship Development Programme at Borisavant Village of Parbhani Dist (Maharashtra)	31-1-11	800	DSR-ITC(ABD)
28	Training to farm women and technology transfer on millet processing for value addition at K.V.K., Jammikunta, Karimnagar Dist, A.P, India	8 March 2010	100	ANGRAU

14. Participation in Conference/ Meetings/Trainings/ Radio talks, etc.

S. No.	Details of Meetings/Seminars/ Trainings/Radio talk, etc.(Name &Address)	Duration (From-To)	Budget (`Rs)	Participant (Name & Address)
1	Training on Technology Commercialization and Innovation Management programme conducted by the Indian School of Business, Hyderabad	29th July- 1st August 2013	free	Dr B Dayakar Rao, CPI
2	FICCI Andhra Pradesh State Council organized 2nd edition of FOOD 360: International seminar on Agribusiness and Food Processing at Hotel Taj Krishna, Hyderabad	5-6 November 2012	10,000	Dr B Dayakar Rao, CPI

3	Assocom-India Pvt. Ltd. New Delhi association with International Crops Institute for the Semi – Arid Tropics (ICRISAT), Hyderabad organized interactive Global Symposium on RTE Foods: ADDRESSING CHALLENGES IN THE VALUE CHAIN IN THE FOOD PROCESSING INDUSTRY Hotel Taj Gateway, Ernakulam (Cochin), Kerala	24-25 September 2012	free	Dr B Dayakar Rao, CPI
4	7th NATIOANAL CONFERENCE ON KVK-2012 at Ludhiana, Punjab	19-21 November 2012	free	Dr B Dayakar Rao, CPI
5	1st ICC India Grains Conference at New Delhi, India	16-18 January 2012	free	-
6	National seminar on Non-biological contaminants (Mycotoxins, pesticides, Heavy metals & Dioxins)in food , feed and their safety standards at New Delhi.	23-24 September 2008	5000	Dr TV Hymavathy
7	Thailand Food conference , ASEAS international conference on Ministry of commerce and food industry network of Thailand at Bangkok, Thailand	3-5th March 2011	15000	Dr TV Hymavathy
8	International conference on Hydrocolloids, Biofunctionality and Techno functionality of Hydrocolloids at Whistler center for Carbohydrate Research, Purdue University, USA	14-18 May 2012	50000	Dr TV Hymavathy
9	Global symposium on ready-to-eat (RTE) foods opportunities for R7D, entrepreneurship and markets at Hotel Taj Banjara, Hyderabad.	25-27 April 2011	free	Dr TV Hymavathy
10	International Conference on Scope of co-operation in Indian food & Grain Processing & packaging	9-11 September 2011	free	Dr TV Hymavathy

	industry on Sorghum based health foods –An emerging opportunity for food industries at Bangalore			
11	World Congress on Biotechnology OMICS at Hyderabad, India	21-23 March 2011	free	Dr TV Hymavathy
12	1st ICC India Grains Conference at New Delhi, India.	16-18 January 2012	free	Dr TV Hymavathy
13	International conference on Bioactive Compounds from Plant Food in Nutrition and Health (ICBPN) at CMC College, Kottayam, Kerala, India.	20-22 September 2012		Dr TV Hymavathy
14	Training to Officers of Development Departments of Southern States from at Extension Education Institute, ANGRAU	9-13 January 2012	free	Dr TV Hymavathy
15	International Conference on Innovative Approaches for Agricultural Knowledge Management at NASC Complex, New Delhi.	9-12 November 2011	free	Dr B Dayakar Rao
16	National Conference on Managing Agri supply chain at IIM-Lucknow	9-11 April 2010		Dr B Dayakar Rao
17	Kharif Sorghum on-farm production orientation workshop	6 June 2010		-do-
18	Workshop on Intensive Market Led Rabi Sorghum Cultivation & Value Addition Opportunities	4 Oct 2010		-do-
19	National Seminar on Millets	12 Nov 2010	self	Dr B Dayakar Rao
20	Brainstorming Session on Millets	13 Nov 2010		-do-
21	18 th Annual AERA Conference	18-20 Nov 2010		-do-
22	24 th Indian Society of Agricultural Marketing National Conference	21-23 Nov 2010		-do-
23	First Zonal Institute Technology Management Committee (ZITMC)	December 2010		-do-

	meeting at CIFT, Cochin			
24	1st Taskforce meeting on Millets Promotion organized by DAC	21 January 2011		-do-
25	Paper presentation at ASEAN's Advanced International Food Conference, Thailand	3-6 March 2011	-	Dr T.V.Hymavathi
26	Paper presentation at World Congress on Biotechnology	21-23 March 2011	Rs.4000	-do-
27	To get training and exposure on sorghum processing and value addition visit at Indian Institute of Crop Processing Technology (IICPT), Thanjavur	29 - 31 October 2010	Rs.19,196	-do-
28	Public private partnership for innovation in Agriculture at Indian Institute of Management, Lucknow	16 – 20 August 2010	---	-do-
29	National Seminar on Millets and Brainstorming Session on Millets	12-13 Nov 2010	free	Mr Nirmal Reddy, Co-PI, ITC ABD
30	National Seminar on Millets and Brainstorming Session on Millets	12 -13 Nov 2010	1500	Dr.MP Rajendra Prasad, Co PI, NIN
31	Kharif Sorghum on-farm production orientation workshop	6 June 2010	---	Dr. Ch.Sashidhar Reddy
32	Workshop on Intensive Market Led Rabi Sorghum Cultivation & Value Addition Opportunities	4 Oct 2010	---	-do-
33	Women entrepreneurship Development workshop at Parbhani	31 Jan 2011	---	P Mukesh

15. National/ Foreign Trainings/ Undertaken (National/ International)

S. No.	Name, Designation and Address of the Person	Place of Training	Area of Training	Time and Duration
1	Dr B Dayakar Rao, CPI	Indian School of Business, Hyderabad	Training on Technology Commercialization and Innovation Management programme	29th July-1st August 2013
2	B Dayakar Rao	Indian Institute of Management, Lucknow, UP, India	Management development Programme on Public-Private partnership for innovation in agriculture.	16-20 August 2010
3	B Dayakar Rao	Bangalore	Brand Summit Organized by CII	February 19-20, 2010
4	B Dayakar Rao	New Delhi	Agri-Marketing summit	December 16-18, 2010.
5	B Dayakar Rao	New Delhi	Participated in Training programme organized by NCAP	2010
6	B Dayakar Rao	Indian Institute of Packaging	Packaging of Food Products, Refresher training	3- 7 June
7	B Dayakar Rao	IIM, Ahmadabad,	Training course on Food supply chain management	February 15-21, 2009
8	TV Hymavathy	MANAGE, Rajendranagar organized by NAIP L & CB project	Technical and administrative support for consortia based research in Agriculture	5-14 October 2009
9	TV Hymavathy	New Delhi, India. Organized by	e-learning course on the ISO 22000 Food Safety	21-24 October

		National Productivity Council (Asian Productivity Organization)	Management System	2008

16. Performance Indicators (from inception to completion)

S. No.	Indicator	Total No.	
1.	No. of production technologies released and/or adopted	10	
2.	No. of processing technologies released and/or adopted	50	
3.	Number of technologies/products commercialized based on NAIP research	9	
4.	No. of new rural industries/enterprises established/ upgraded	5	
5.	No. of product groups for which quality grades developed and agreed (breakfast cereals, snack foods, extruded foods, beverages, staples, biscuits and bakery, Instant foods)	7	
6.	Total no. of private sector organizations (including NGOs) participating in consortium	17	
7.	No. of farmers involved in consortia activities	1500	
8.	Total number of farmers' group developed for marketing and processing	10	
9.	Number of patent/intellectual property protection applications filed based on NAIP research	2	
10.	Number of patents/intellectual property protections granted/published based on NAIP research	-	
11.	Number of scientists trained overseas in the frontier areas of science	-	
12.	Number of scientists trained overseas in consortium-based subject areas	-	
13.	No. of scientists participated in conference/seminar etc. abroad		
14.	No. of training organized/ farmers trained	28 trainings	4000 people (Approx)
15.	Success stories	2	

16.	Incremental employment generated (person days/year/HH)	Baseline	Final
		-	81000 (Approx)
17.	Increase in income of participating households (` per annum)	Baseline	Final
		9265/ha	22063/ha
18.	Number of novel tools/protocols/methodologies developed		
19.	**Publications**		
	Articles in NAAS rated journals	2	
	Articles in other journals	4	
	Book(s)	7	
	Book chapter(s)	2	
	Thesis	9	
	Popular article(s) (English)	12	
	Newspaper article(s)	4	
	Seminar/Symposium/Conference/Workshop Proceedings	10	
	Technical bulletin(s)	6	
	Manual(s)	5	
	CDs/Videos	10	
	Popular article(s) in other language	3	
	Folder/Leaflet/Handout	5	
	Report(s)	7	

17. Employment Generation (man-days/year)

S. No.	Type of Employment Generation	Employment Generation up to End of Sub-project	Responsible Partner
1	On-farm production	53000	DSR & ITC
2	Processing, popularization and Marketing	28000	DSR & ITC

18. Assets Generated

(i) Equipment/ Vehicles/ Research Facilities

S. No.	Name of the Equipment with Manufacturers Name, Model and Sr. No.	Year of Purchase	Quantity (Nos.)	Total cost (`in lakhs)	Responsible Partner
1	Furniture	2008	---	0.64	DSR
2	Handy camera (Sony)	2008	1	0.50	DSR
3	Micro-oven (Kenstar)	2008	2	0.21	DSR
4	Convection Oven	2008	1	0.55	DSR
5	Roti making Machine	2008	1	0.21	DSR
6	Digital pocket Refractometer (PAC-1)	2008	1	0.11	DSR
7	Furniture	2008	--	0.65	DSR
8	Foot Operated Sealing 1Machine	2008	1	0.10	DSR
9	Flour Mill Medium & Pulvizer	2008	1	0.69	DSR
10	Quartz Double Distillation Unit	2008	1	0.82	DSR
11	Automatic roti making machine (KMR-II)	2009	1	10.23	DSR
12	Water bath shaker DUBNOFF incubator shaker	2009	1	0.42	DSR
13	Water Activity meter (Hygropalm AWI-Set/14 Rotronic ag. Switzerland)	2009	1	1.52	DSR
14	De- Stoner	2009	1	1.22	DSR
15	Roti Making Machine (big) /Chapathi Kings	2009	1	9.99	DSR
16	Grain Grading Machine	2009	1	4.50	DSR
17	Semolina/ Suji/ Rava Making Mach	2009	1	15.31	DSR
18	Parboiling Tanks	2009	1	2.56	DSR
19	Biscuit Making Machine	2009	1	3.16	DSR
20	Rice Flaking Machine	2009	1	7.97	DSR
21	Air Conditioner 1.5 ton	2009	1	0.31	DSR
22	Laptop Computer (HP)	2009	1	1.03	DSR

23	Fiber Tech Unit including muffle	2009	1	16.49	DSR
24	Desktop Computer (HP)	2009	1	0.80	DSR
25	Dehuller (2)	2009	1	1.19	DSR
26	Extruder	2009	1	11.00	DSR
27	Furniture	2009	--	1.83	DSR
28	Furniture	2009	--	3.91	DSR
29	Packing Machine	2009	1	1.5	DSR
30	Platform Balance	2009	1	0.30	DSR
31	Swaraj Mazda Van	2009	1	9.90	DSR
32	Van Fabrication	2009	1	5.28	DSR
33	Small Biscuit machine	2009	1	1.68	DSR
34	Water Purification System	2009	1	1.79	DSR
35	Desk computer & printer	2011	1	--	DSR
36	Hot extruder (lab scale)	2013	1	16.72	DSR
37	Texture Analyzer (Food textometer)	2013	1	14.25	DSR
38	Viscometer	2013	1	22.13	DSR
39	Coating pans	2013	1	4.03	DSR
40	Water purification system	2013	1	5.18	DSR
41	Falling water apparatus	2013	1	8.34	DSR
42	Phase contrast microscope	2013	1	7.88	DSR
43	Semolina making machine	2013	1	16.84	DSR
44	Cookie making machine	2013	1	24.81	DSR
45	Rancidometer	2013	1	24.52	DSR
46	High Power UPS 15 KW	2013	1	18.94	DSR
47	Puff Gun Systems	2013	1	15.23	DSR
48	Water Activity Analyzer	2013	1	US$11,200	DSR
49	Laser Thermometer	2013	1	0.378	DSR
50	Ribbon Blender	2013	1	0.916	DSR

(ii) Works

S. No.	Particulars of the Work, Name and Address of Agency Awarded the Work	Year of Work Done	Quantity (Nos.)	Total Cost (`)	Responsible Partner
1	Renovation for Millet processing lab	------	1	1,99,700	ANGRAU

2	Fibre Sheet roofing in front of grain	------	1	378000	DSR
3	Replacement of Old Asbestos sheet roofing	------	1	201000	DSR
4	Renovation and repair of lab	------	1	694000	DSR
5	Const. of Shed	-------	1	550000	DSR

(iii)Livestock

(Details of livestock procured/produced in the sub-project)

S. No.	Details of Livestock (Breed, etc.)	Year of Procurement/Production	Nos.	Total Cost (`)	Responsible Partner
	NA				

(iv) Revenue Generated

(Details may be given on revenue generated in the sub-project viz., sale of seeds, farm produce, products, patents, commercialization, training, etc.)

S. No.	Source of Revenue	Total amount (`Rs)	Responsible Partner
1	Royalty Fees from Entrepreneurs	2,60,000	DSR
2	Counter sale in DSR	5,60,000	DSR
3	Consignments of Heritage and ITC	6,40,000	DSR
4	Sale in exhibitions , trade fair etc	3,00,000	DSR
5	R&D	30,00,000	DSR
	Total Amount	47,60,000	

19. Awards and Recognitions

S. No.	Name, Designation, Address of the Person	Award/ Recognition (with Date)	Institution/ Society Facilitating (Name & Address)	Responsible Partner
1	DSR	South Indian Hospitality Award 2013	South Indian Hospitality Association	DSR
2	DSR	Best food Innovator Award FICCI Award 2013	FICCI, Hyderabad	DSR
3	B Dayakar Rao & team	NAIP-Appreciation award on July 19, 2012	PIU-NAIP	DSR, ITC, ANGRAU & NIN
4	B Dayakar Rao	DSR has been identified as Centre of Excellence for Sorghum processing and value addition under INSIMP in June 2011 and earned funding Rs 95 lakhs	DAC, Ministry of Agriculture, Govt. of India	DSR
5	B Dayakar Rao	Appointed as Task force member by Secretary, Agriculture, Govt of India for devising millet promotion programme in the country in November, 2010	DAC, Ministry of Agriculture, Govt. of India	DSR
6	B Dayakar Rao	Appointed as Nodal Officer for Implementation of INSIMP project on establishment of Millet processing clusters covering 25000 villages in 1000 mandals across the millet growing states	DAC, Ministry of Agriculture, Govt. of India	DSR

		in the country under the Rashtriya Krishi Vikas Yojana.		
7	B Dayakar Rao	Appointed as Member, Board / advisory council of ASSOCOM, New Delhi	ASSOCOM, New Delhi	DSR
8	B Dayakar Rao	Our stall is awarded as best popularization effort at National Symposium on genomics being held at ANGRAU, Hyderabad in February 2010.	ANGRAU, Hyderabad	DSR
9	B Dayakar Rao	Nominated as a member of Zonal Technology management Unit of ICAR (NAIP) whose purview is to review 21 ICAR Research institutes in south zone.	PIU-NAIP	DSR
10	B Dayakar Rao	Won the Best poster presentation in National Seminar on Food security & processing , Thrissur, September 2008, " Approaches for commercialization of sorghum through value-addition & entrepreneurship development"	Indian Institute of Crop Processing Technology, Thrissur	DSR
11	B Dayakar Rao & team	Our NAIP subproject was chosen for presentation of Review among all the component II projects at PIU in June 2008 representing all ICAR Institutes and RPC Chairman rated it as	PIU-NAIP	DSR, ITC, ANGRAU & NIN

		excellent.		
12	B Dayakar Rao & team	Rated NAIP-MVC project under highly satisfactory category.	World bank	DSR, ITC, ANGRAU & NIN

20. Steps Undertaken for Post NAIP Sustainability

1. MoU's with private entrepreneurs for extensive Commercialization of Sorghum processed products in the market.
2. Improved production technologies leveraging eChoupal platform of ITC for higher yields
3. End product specific production orientation to farmers for increasing returns.
4. Marketing of eatrite products – Heritage Fresh Retail Stores in Hyderabad
5. Publicity campaigns and other promotional support for Millet promotion through Road shows, Nutritional Campaigns and Exhibitions.
6. Support from Government based programmes such as INSIMP for technology backstopping to the entrepreneurs across the country

21. Possible Future Line of Work

- Tie ups with entrepreneurs for up-scaling of production of processed foods
- Replication of the model elsewhere in the country through Government's (DAC's Millets promotion) programme involving all the stakeholders
- Centralized Processing facility with continuous R&D and Entrepreneurship Development facility at DSR will be upgraded and maintained to meet the intended objectives
- Creating processing facilities at farm level with market linkages is a measure of sustainability
- To engage in those business plans which accrue maximum share to producers in the consumer rupee.
- To develop and standardize some more ready-to-eat/cook products such as *dosa*batter, ready *upma* mix, powdered *dosa* mix, Lassietc as they have greater potential for commercialization.
- To rope in bigger players such as Britannia, Nestle, ITC foods, Bambino to engage in targeted products for their commercialization in volumes
- Aggressive marketing strategies with communication plans such as advertisement
- To partner with government agencies & retail chains for commercialization of sorghum products through MoU's at various business model.
- To extend sorghum marketing to Bangalore and Pune besides Hyderabad & non-traditional Delhi

22. Personnel

	From – To (DD/MM/YYYY)
Research Management (CL)	
1. Dr JV Patil, Director, DSR, Hyderabad	01/09/2010 To 31/03/2014
2. Dr SV Rao, Acting Director, DSR, Hyderabad	01/03/2010 To 31/08/2010
3. Dr N Seetharama, Ex-Director, DSR, Hyderabad	20/12/2007 To 28/02/2010
Scientific (CPI, CCPI, others)	
4. Dr B Dayakar Rao, Principal Scientist, DSR (CPI)	20/12/2007 To 31/03/2014
5. Dr MP Rajendra Prasad, Deputy Director, NIN	20/12/2007 To 31/03/2012
6. Mr K Nirmal Reddy, General Manager, ITC (ABD) Ltd., Secunderabad	20/12/2007 To 31/03/2013
7. Dr Kamini Devi, Professor, College of Home Science, ANGRAU	20/12/2007 To 31/08/2010
8. Dr TV Hymavathy, Associate Professor, College of Home Science, ANGRAU	01/09/2010 To 31/03/2013
9. Dr CV Ratnavathi, Principal Scientist (Biochemistry), DSR	20/12/2007 To 30/11/2009
10. Dr Ch Shashidhar Reddy, Principal Scientist (Extension), DSR	20/12/2007 To 31/03/2014
11. Dr Shyam Prasad, Principal Scientist (Entomology), DSR	20/12/2007 To 30/11/2009
12. Dr KN Ganapathy, Scientist (Plant Breeding), DSR	01/05/2010 To 31/03/2014
13. Mr P Mukesh, Scientist (Sr. Scale (Computer))	01/05/2010 To 31/03/2014
Technical (CPI, CCPI, others)	
14. Ms Annapurna, T 7, DSR	
15. Mr Pramod Kumar, T 7-8, DSR	
16. Ms AD Vishala, T8, DSR	**Continued till date**

23. Governance, Management, Implementation and Coordination

A. Composition of the various committees (CIC, CAC, CMU, etc.)

S. No.	Committee Name	Chairman (From-To)	Members (From-To)
1.	**CIC**		
	Dr JV Patil Dr SV Rao Dr N Seetharama	01/09/2010 To 31/03/2014 01/03/2010 To 31/08/2010 20/12/2007 To 28/02/2010	
	Dr MP Rajendra Prasad, Deputy Director, NIN		20/12/2007 To 31/03/2012
	Mr K Nirmal Reddy, General Manager, ITC (ABD) Ltd., Secunderabad		20/12/2007 To 31/03/2013
	Dr Kamini Devi, Professor, ANGRAU Home Sceince		20/12/2007 To 31/08/2010
	Dr TV Hymavathy, Associate Professor, ANGRAU Home Science		01/09/2010 To 31/03/2013
	Dr B Dayakar Rao, Principal Scientist, DSR (CPI)	**Secretary**	20/12/2007 To 31/03/2014
2.	**CAC**		
	Dr. A. Seetharam, Former Project Coordinator, Dr NGP Rao. Ex-Director, DSR	Chairman	
	Dr. Ramesh V Bhat, Ex-Deputy Director, NIN		
	Dr. Vijaya Khader, Retd. Professor, ANGRAU		
	Prof. G. Pakki Reddy, Executive Director, Agro-Biotech Foundation, A.P.		
	Dr. JP Singh, Director, Directorate of Millets		

	Development (DMD)		
	Mr. Vinayak Rao Patil (Progressive farmer)		
	Ms. Chinnamma Thomas, President, Rural Development Society (RDS)		
	Dr R Ezekiel, NC Dr. R K Goyal, National Coordinator (Component-II) NAIP Dr JP Mittal		Member
	Dr. J V Patil, Director, Directorate for Sorghum Research (DSR)		Member
	Dr. B Dayakar Rao, Principal Scientist (Agril. Economics), Directorate for Sorghum Research (DSR)		Secretary 20/12/2007 To 31/03/2014
3.	**CMU**		
	Dr. HS Talwar, Principal Scientist, DSR, Rajendranagar, Hyderabad-30	20/12/2007 To 31/03/2014	
	Dr. B. Dayakar Rao, CPI & Principal Scientist, DSR, Rajendranagar, Hyderabad-30		20/12/2007 To 31/03/2014
	Dr. C Aruna Reddy, Principal Scientist, DSR, Rajendranagar, Hyderabad-30		

List of Meetings organized (CIC, CAC, CMU, etc.)

S. No.	**Details of the meeting**	**Date**	**Place & Address** (of meeting was organized)
1.	**CIC**		
	I CIC	16 .01.08	DSR
	II CIC	6.05.08	DSR
	III CIC	27.10.08	DSR
	IV CIC	12.05.09	DSR
	V CIC	11.06.10	DSR
	VI CIC	28.05.11	DSR
	VII CIC	16.10.12	DSR
2.	**CAC**		
	I CAC	05.02.08	DSR
	II CAC	09.05.08	NIN
	III CAC	10.07.09	ANGRAU
	IV CAC	26.06.10	ITC
	V CAC	31.05.11	DSR
	VI CAC	25.03.13	DSR

Part-III: Budget and its Utilization

STATEMENT OF EXPENDITURE (Final)

(Period from 20.12.2007 **to** 31.03.2014**)**

Sanction Letter No. :

Total Sub-project Cost `: 580 lakhs

Sanctioned/Revised Sub-project cost: Rs 881.27 lakhs

Date of Commencement of Sub-project: 20.12.2007

Duration: From 20/12/2007 to 31/03/2014

Funds Received in each year (in lakhs)

I Year ` **:** 30.85

II Year ` **:** 249.89

III Year ` **:** 46.50

IV Year' **:** 60.74

V Year' **:** 78.20

VI Year' **:** 62.24

VII Year' **:** 265.21

Bank Interest received on fund: Rs. 43,992

Total amount received: Rs. 8, 42, 63, 400

Total expenditure: Rs. 7, 75, 85,400

Expenditure Head-wise: Given below tables

* Institutional charges will be 10% of the recurring contingencies for the Lead Consortium and 5% for Consortia Partners.

Name & Signature of CPI :	**Name & Signature of Competent Financial authority:**
Date:_____	**Date:_____**
Date:_____	**Signature, name and designation of Consortia Leader**

Lead Institute: Directorate of Sorghum Research (Rs. in lakhs)

STATEMENT SHOWING THE DETAILED GRANT IN AID RELEASED AND EXPENDITURE INCURRED																		
Sanctioned		**Funds Released**							**Expenditure Incurred**									
A. Recurring Contingencies	**Funds Allocation(*)**	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**	**6th Year**	**7th Year**	**1st Year**	**2nd Year**	**3rd Year**	**4th Year**	**5th Year**	**6th Year**	**7th Year**	**Total Releases**	**Total Expenditure**	**Refund**	**Balance as on 2014**
1.TA	13.83	0.35	2.5	1.22	2.50	1.99	0.69	1.64	0.62	1.22	2.59	2.41	1.73	1.02	1.16	10.89	10.75		0.14
2.Workshop	6.92	0.38	2.06	1.32	0.39	0.30	0.96	1.64	0.19	1.32	0.39	0.55	0.48	0.56	0.30	5.12	3.79		1.94
3.Contractual Staff	53.87	1.25	5.45	6.60	9.09	7.35	11.02	9.14	0.10	6.88	6.08	7.01	7.92	11.27	10.59	47.91	49.85		0.06
4.Operational Cost	205.72	2.25	22.14	15.01	25.20	54.33	37.18	31.8	1.69	15.31	20.60	37.48	43.84	35.20	22.603	180.20	176.72		11.19
Sub Total of A (1-4)	**280.35**	**4.23**	**32.16**	**24.15**	**37.17**	**63.97**	**47.93**	**44.21**	**2.60**	**24.73**	**29.65**	**47.44**	**53.96**	**48.05**	**34.05**	**244.11**	**240.48**		**13.33**
B. HRD Component																			
5.Training	0.75	0.38	3.63	0.50	1.00	0.50	0.25							0.05		3.25	0.05	3.00	0.70
6.Consultancy		0.25	3.75	1.00	3.00		0.50									0.50			0.0
Sub Total B (5-6)	**0.75**	**0.63**	**7.38**	**0.50**	**4.00**	**0.50**	**0.75**							**0.05**	**0.00**	**3.75**	**0.05**		**0.70**

7.Equipment	326.44	18.10	92.1		0.75	0.91		221.00	2.00	101.44	0.32	0.51			178.7	331.04	282.97		42.30
8.Furniture	9.77	2.00	6.75		1.25	0.23			1.96	6.57		1.24				9.77	9.77		0.00
9.Work/New/Renovation	25.76	-	20							19.48	2.90	3.37				20.00	25.76		0.00
10. Other Books	0.90	-	2	1.50		1.10	0.34			0.90			1.16			2.06	2.06		0.00
Sub Total C (7-10)	**362.87**	**20.10**	**120.82**	**1.50**	**2.00**	**2.24**	**0.34**	**221.00**	**3.96**	**128.40**	**3.22**	**5.13**	**1.16**		178.7	**362.87**	**320.57**		**42.30**
D. Institutional Charges	23.79	0.42	3.41	0.27	3.46	3.81	1.68		0.85	0.31	1.19	5.53	3.50	0.65	-	13.05	12.03		1.04
Grand Total (A+B+C+D)	**667.76**	**25.37**	**163.79**	**25.42**	**39.63**	**65.05**	**50.03**	**265.21**	**7.42**	**153.44**	**34.06**	**58.10**	**58.63**	**48.74**	**212.76**	**623.78**	**573.15**		**57.36**

Institute: National Institute of Nutrition

STATEMENT SHOWING THE DETAILED GRANT IN AID RELEASED AND EXPENDITURE INCURRED

Sanctioned	**Funds Released**					**Expenditure Incurred**					**Total Funds Released**	**Total Expenditure**	**Refund**
A. Recurring Contingencies	1st (2007-08)	2nd (2008-09)	3rd (2009-10)	4th (10-11)	5th (11-12)	2007-08	2008-09	2009-10	2010-11	2011-12			
1. TA	12,500	12,500	25,000	32,921	-11,852		33,796	22,171	38,148	15,614			
2. Workshop						280						280	
3. Contractual Staff	75,000	130,703	400,000	655,200	639,600	5,703	3,99,671	4,03,641	639,600	4,63,748	19,00,503	19,12,363	
4. Operational Cost	50,000	655,000	975,559	519,968	-48,470	52,706	9,02,048	7,65,718	331,530	3,29,981	21,52,057	23,81,983	
Sub Total of A (1-4)	**137,500**	**798,203**	**1,400,559**	**1,208,089**	**579,278**	**58,689**	**13,35,515**	**11,91,530**	**10,09,278**	**8,09,343**	**41,23,629**	**44,04,355**	
B. HRD Component													
5. Training		75,000		25,000	-100,000								
6. Consultancy													
Sub Total B (5-6)		**75,000**		**25,000**	**-100,000**								
C. Non-Recuring Contingency													

7. Equipment	175,000	2,825,000					175,679	25,69,476			30,00,000	27,45,155	
8. Furniture		75,000	25,000				18,506				1,00,000	18,506	
9. Work/New/Renovation	25,000	100,000	75,000								2,00,000		
10. Other Books	25,000	50,000	50,000	25,000				95,529			1,50,000	95,529	
Sub Total C (7-10)	**225,000**	**3,050,000**	**150,000**	**25,000**			**194,185**	**26,65,005**			**34,50,000**	**28,59,190**	
D. Institutional Charges	6,900	44,000	44,000	58,000	16,077	6,900	44,000	88,000	25,317	12,995	1,68,977	1,77,212	
E. Bank interest					43,992						43,992		43,992
Grand Total (A+B+C+D)	**3,69,400**	**39,67,203**	**15,94,559**	**13,16,089**	**5,39,347**	**65,589**	**15,73,700**	**39,44,535**	**10,34,595**	**8,22,338**	**77,86,598**	**74,40,757**	**43,992**
*Tender documents charges=2500, Refund of Advance=11310, excess expenditure petains 2008-09=1749													

Institute: ITC (ABD) Ltd

Sanctioned Heads	Funds Allocated (*)	Funds Released						Expenditure Incurred						Total Releases	Total Expenditure	Refund
		2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13			
A. Recurring Contingencies																
(1) TA		5,000	74,487	75,000	75,000	(42,001)	3,831	4,467	77,221	23,256	9,743	29,130	42,134	1,91,317	1,85,951	-
(2) Workshops		5,000	1,95,000	1,99,293	2,00,000	1,09,005	34,891		1,99,293	98,878	2,60,127	1,44,891		7,43,189	7,03,189	-
(3) Contractual Services/RA/SRF		40,000	1,99,100	1,75,950	3,74,400	3,17,400	1,12,970	39,100	1,75,950	2,34,600	3,17,400	3,17,400	3,17,400	12,19,820	14,01,850	-
(4) Operational Expenses		1,00,000	13,00,000	9,00,000	4,79,910	9,00,000	6,37,170	1,13,000	13,04,015	4,79,910	12,26,076	6,31,579	3,80,789	43,17,080	41,35,369	-
Sub-Total of A (1-4)		**1,50,000**	**17,68,587**	**13,50,243**	**11,29,310**	**12,84,404**	**7,88,862**	**1,56,567**	**17,56,479**	**8,36,644**	**18,13,346**	**11,23,000**	**7,40,323**	**64,71,406**	**64,26,359**	-
B. HRD Component																
(5) Training		25,0	1,25		1,00,000	(1,50,00	(75,000)							25,000		-

		00	,000			0)										
(6) Consultancy																
Sub-Total of B (5-6)		**25,000**	**1,25,000**		**1,00,000**	**(1,50,000)**	**(75,000)**							**25,000**		-
C. Non-Recurring																
(7) Equipment																
(8) Furniture																
(9) Works (new renovation)																
(10) Others (Animals, Books, etc.)																
Sub-Total of C (7-10)																
D. Institutional Charges*		7,500	68,750	68,000	84,318	65,771	28,951	16,000	68,751	51,459	91,659	56,151	37,016	3,23,290	3,21,036	-
Grand Total (A+B+C+D)		**1,82,500**	**19,62,337**	**14,18,243**	**13,13,628**	**12,00,175**	**7,42,813**	**1,72,567**	**18,25,230**	**8,88,103**	**19,05,005**	**11,79,151**	**7,77,339**	**68,19,696**	**67,47,395**	**72,301**

Institute: ANGRAU

Sanctioned Heads	Funds Allocated (*)	Funds Released						Expenditure Incurred						Total Releases	Total Expenditure
		1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year		
A. Recurring Contingencies															
(1) TA	1,50,000	5,000	35,000	-25,000	30,000	30,000	70,000	Nil	Nil	Nil	30,000	17,104	16,996	1,70,000	64,100
(2) Workshops	95,000	5,000	20,000	-17,500	15,000	-7,500	15,000	Nil	Nil	12,885	Nil	Nil	13,770	37,500	26,655
(3) Contractual Services/RA/SRF	9,80,000	40,000	1,60,000	80,156	3,74,400	3,67,050	4,27,800	Nil	1,80,156	2,52,450	3,14,600	3,43,200	4,18,600	14,49,406	15,09,006
(4) Operational Expenses	17,40,000	20,000	5,09,750	1,36,881	2,50,000	3,49,931	6,50,000	4,750	4,49,381	1,60,516	2,49,931	3,49,808	6,49,972	19,16,562	18,64,358
Sub-Total of A (1-4)	**29,65,000**	**70,000**	**7,24,750**	**1,74,537**	**6,69,400**	**7,46,981**	**11,62,800**	**4,750**	**6,29,537**	**4,25,851**	**5,94,531**	**7,10,112**	**10,99,338**	**35,73,468**	**34,64,119**
B. HRD Component															
(5) Training	4,10,000	5,000	1,20,000	-75,000	1,00,000	34,490	Nil	Nil	Nil	Nil	59,490	41,301	Nil	2,59,490	1,00,791
(6) Consultancy	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sub-Total of B (5-6)	**4,10,000**	**5,000**	**1,20,000**	**-75,000**	**1,00,000**	**34,490**	**Nil**	**Nil**	**Nil**	**Nil**	**59,490**	**41,301**	**Nil**	**2,59,490**	**1,00,791**

C. Non-Recurring															
(7) Equipment	20,00,000	1,00,000	15,00,000	3,00,000	Nil	Nil	Nil	Nil	15,90,134	47,950	3,13,973	Nil	Nil	19,00,000	20,13,907
(8) Furniture	2,00,000	Nil	1,00,000	Nil	Nil	Nil	Nil	Nil	99,973	37,923	61,850	Nil	Nil	1,00,000	1,37,896
(9) Works (new renovation)	2,00,000	Nil	2,00,000	Nil	Nil	Nil	Nil	Nil	1,99,700	Nil	Nil	Nil	Nil	2,00,000	1,99,700
(10) Others (Animals, Books, etc.)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Sub-Total of C (7-10)	**24,00,000**	**1,00,000**	**18,00,000**	**3,00,000**	**Nil**	**Nil**	**Nil**	**Nil**	**18,89,807**	**85,873**	**3,75,823**	**Nil**	**Nil**	**22,00,000**	**23,51,503**
D. Institutional Charges*	1,48,000	3,500	35,500	13,500	25,000	38,470	58,140	Nil	35,500	13,500	25,000	38,470	58,131	1,74,110	1,70,601
Grand Total (A+B+C+D)	**59,23,000***	**1,78,500**	**26,80,250**	**5,13,037**	**7,94,400**	**8,19,941**	**12,20,940**	**4,750**	**25,54,844**	**5,25,224**	**10,54,844**	**7,89,883**	**11,57,469**	**62,07,068**	**60,87,014**

*The sanctioned amount of Rs.59,23,000 was given for the project period from 2007 to June 2012 but the release was high due to the project extended till March 2013

PART-IV: DECLARATION

This is to certify that the final report of the Sub-project has been submitted in full consultation with the consortium partners in accordance with the approved objectives and technical programme and the relevant records, note books; materials are available for the same.

Place:_____

Date:_____ Signature of Consortium Principal Investigator

Signature & Date

Consortium Co-Principal Investigator

Signature & Date

Consortium Co-Principal Investigator

Signature & Date

Consortium Co-Principal Investigator

Signature & Date

Consortium Co-Principal Investigator

Comments & Signature of Consortium Leader

Date:

Pro-forma 1

1) **Title of the sub-project:** Creation of demand for millet foods through PCS Value Chain

2) **Name of CPI/ CCPI:** Dr. B Dayakar Rao, CPI, DSR

Dr.MP Rajendra Prasad, CoPI, NIN

Mr. K Nirmal Reddy, CoPI, ITC

Dr. TV Hymavathi, Co PI, ANGRAU

Dr. Kamini Devi, Co PI, ANGRAU (from 20.12.2007 to 31.08.2010)

3) **Title of the technology:**

"Creation of Demand for millets through value chain model"

To create demand for millets, DSR has worked on identification of suitable genotypes for improved cultivation and production of sorghumin in *rabi* and *kharif* seasons. A set of 51 lines including parental lines, released varieties, germplasm lines and breeding lines were evaluated for protein digestibility, an important nutritional trait which enhances the nutritive value of sorghum. End-specific improved cultivars CSH-14, CSH-16, CSH-23, CSV-20 and SPH-1148 in *kharif* and M 35-1, CSV 216 R (Phule yashoda) & SPV 1411 (Parbhani moti), phule vasudha and phule revati in *rabi* were identified for production sorghum foods. The end-product specific on-farm production was facilitated on the lines of successful models of ITC's *e-choupal*. In this model, farmers were given market buy-back assurance for (Fairly Accepted Quality) FAQ grain (In case if they do not find a market or appropriate price, ITC will procure and is aggregated from small holder's marketed surplus). ITC-ABD facilitated integrated farm extension services in private-public partnership (PPP) mode on procurement, extension, dissemination of knowledge and information including daily market prices in various markets through the computers placed in *e-choupal sanchalak's* (village representative) house which is accessible to all the participating farmers in the village. The procurement of participating farmers' produced through buy-back mechanism, and sharing the knowledge are either facilitated or undertaken directly by ITC Ltd. The assurance of buyback gave motivation to the participating farmers to employ gainful crop management practices which led to higher income. In fact, the income of those participating farmers whose produce was procured, increased by 44 per cent over the baseline income, while those whose produce was not procured, income increased by 36 per cent. From the study we could infer that sorghum when cultivated on an intensive scale with backstopping of technology and farm extension services impacted yield and income levels. The end-product specific production also had another advantage of linking up with entrepreneurs who actually bought the identity preserved produce which was procured and aggregated for engaging in small-scale production of specific sorghum products.

Processing technologies for the production sorghum foods were developed at CFTRI, Mysore, DSR and ANGRAU and for pearl millet foods at ANGRAU. More than 50 technologies were developed using different methods such soaking, malting, germination, dehulling, parboiling, milling, baking, flaking, fermentation, and extrusion cooking. Sorghum foods such

as dehulled sorghum, malted sorghum, sorghum flour, multi grain flour , coarse, medium and fine semolina, parboiled semolina, flakes, roasted flakes, vermicelli and pasta, biscuits, protein rich snacks, cakes, fermented foods such as lassi, Instant foods, tastemakers and technologies for utilization of byproducts of sorghum. More than 35 sorghum recipes were standardized. Studies were conducted for the extension of shelf life of millet foods (sorghum & pearl millet) using different packaging materials and suitable packaging material has been used for commercialization. Nutritional evaluation of sorghum foods was done at NIN, Hyd. Results from various studies such as organoleptic evaluation, glycemic index and glycemic load, evaluation of sorghum foods in diabetic patients and school children and protein digestibility in animals proved that sorghum can be used as a safe food in for all age groups and benefits can be attained on inclusion of sorghum in the diet.

Creation of awareness about millets has been done successfully in using all the possible mediums such as pamphlets, leaflets, newspapers, books, jingles, participating in various road shows, campaigns, exhibitions, TV shows, radio talks, seminars, conferences, workshops and conducting training programs for entrepreneurs and farmers. Awareness about millets was also created through internet such as creation of website *eatrite* (DSR registered brand name for sorghum foods) and information about millets on different websites. The policy makers are sensitized about the importance of sorghum and other millets for potentiality of uplifting the living standards of dry-land farmers.

In order to find out the consumer acceptability, feasibility and sustainability of newly developed sorghum RTE and RTC products under the DSR brand name 'Eatrite' in the market, the study was conducted in traditional sorghum consuming city of Hyderabad and Pune, and non-traditional Delhi during 2012. The techno-economic feasibility of sorghum-processed products was conducted viz., Jowar rich multigrain atta, Jowar rawa, Jowar vermicelli, Jowar pasta, Jowar biscuits, Jowar flakes. The result shows feasibility and profitability of sorghum processing with respect to cost incurred and market demand. Consequently, commercialization of these products has been initiated by the DSR in partnership with private players.

With the above mentioned initiatives has successfully created demand for sorghum foods through value chain model. This model can be taken up for the creation of demand for other millets.

4) Information on existing farming systems, practices, productivity levels and income in the target area:

A four year study was conducted during *kharif* of which two years were (2008 and 2009) in Adilabad, Andhra Pradesh and the next two years (2010 and 2011) in Nanded, Maharashtra and during *rabi* in Parbhani, Maharashtra from 2008-09 to 2011-12. Baseline survey was conducted in these districts before starting the project with 100 farmers (25 farmers in each village) selected, so as to establish benchmarks for impact analysis of the interventions executed in this pilot scale value chain on sorghum foods. From each selected district, 500 participating farmers covering 20 e-*choupals* were identified under different landholding categories and each farmer was provided with 3 kg of seed of improved cultivars (CSH-14, CSH-16, CSH-23, CSV-20 and

SPH-1148 in *kharif* and M 35-1, CSV 216 R (Phule Yashoda) & SPV 1411 (Parbhani Moti), Phule Vasudha and Phule Revati in *rabi*). Thus, a total of 1000 farmers were brought under 400 ha in an year. The production of grain in *kharif* was 18.78 q/ha and stalk was 75.18 q/ha and in rabi, it was 14.8 q/ha and 58.2 q/ha, respectively and the average grain yield and stalk yield recorded during four years of the project was 16.79 q/ha and 66.69 q/ha, respectively. The net returns incurred during *kharif* are less when compared to *rabi* because the price of the grain during *kharif* was less due to its inferior quality as a result of molding due to heavy rainfall at the time of harvesting and so it was unfit for consumption. The average increase in net income (rabi and kharif seasons) amounted to 138 % over the baseline income (Rs.9265/ha to rs.22063/ha).

With buy back assurance given to the farmers, almost all the farmers followed recommended package of practices though obviously there were some constraints in the procurement of the inputs required. Price of sorghum increased year by year and the market price could be assured to farmers through buy back assurance. This is the first time they have concentrated on sorghum and spent much time in adopting all the practices. They never knew that sorghum also can have these many alternative uses. By knowing all food products prepared from sorghum and the impact of adopting the recommended practices, farmers are now enthusiastic about the sorghum crop and want to continue the same kind of practices in future also.

5) **Key Intervention(s) introduced:** Orientation on improved method of sorghum cultivation; distribution of package of practices (PoP) and improved seeds; extension services; buy-back facilitation, processing interventions and flagging of sorghum as nutria-cereal.

6) Results

Status of dissemination/ commercialization; and, extent of adoption and success, if applicable; with supporting data (with tables and photographs as annexure):

More than 50 processing technologies were developed by the DSR lead consortium. Among the technologies, DSR has adopted 9 technologies for commercialization of sorghum foods after conducting a study on consumer acceptability, feasibility and sustainability of sorghum RTE and RTC products foods. The adopted technologies for commercialization of sorghum foods have created a tremendous demand, entering MoU with 17 firms which include the key player in the food processing industry, Britannia India Pvt. Ltd.

7) Brief description of technology for release:

Technologies for Instant foods such as Idli, dosa, upma, pongal, kheer mix, flakes kheer mix, museli, choco biscuits, masala flakes and pops, tastemakers for pasta.

8) Expected Outcome/ Impact of the technology:

8.1. Expected increase in area, production and net income

8.2. Others

9) Whether findings have been published? If so, give the citation and enclose copy of the publication. Yes. Please find enclosed copy- publications

10) Any other information.

Note: Use separate pro-forma for each technology

Attach photograph(s) relevant to the technology

Pro-forma 2

1) **Title of the sub-project:** Creation of demand for millet foods through PCS Value Chain
2) **Name of CPI/ CCPI:** B Dayakar Rao, CPI, DSR
3) **Title of the technology:** Sorghum Ready-to-Eat/Cook (RTE/C) Foods
4) Commercialization status with date of licensing/ MOU: Started in 2010 with the soft launching of DSR brand 'Eatrite'at NAFED Bazaar, Krishi Bhawan, New Delhi with the tag line 'Eat Jowar Stay Healthy'.
5) **Brief description of intervention/ innovation:** DSR has developed more than 30 product technologies under NAIP. However, based on market potentiality, 9 products have been commercialized. The products are labeled and packed in specially designed packets through professional agencies with nutritional profile and other mandated information scribed on it. DSR has registered a brand name "eatrite" with a tag line Eat Jowar –stay healthy. The packet also gives information on recipe that can be made from the product. The details of these products are given in the below table. These convenient and healthy products are targeted primarily urban population. The products are aggressively promoted through road-shows, nutritional campaigns, print and electronic media across the Hyderabad City on a pilot scale. Currently they are marketed by M/s Heritage Fresh retail chain stores and are explored for their market in unorganized market. The response has been very good and there is increasing demand for their availability across the city and other major metros. Particularly, multigrain *atta*, pure *jowar* biscuits, flakes have good demand across all age groups. DSR has signed with private entrepreneurs so as to make available these products on-shelf across the metros. These products are tested for their nutrient profile and nutritional suitability by National Institute of Nutrition (NIN), Hyderabad and ascertained that they are recommended for those who are ailing from life style disorders such as diabetes and obesity, and beneficial for all age groups.

S No	Name of the product	SKU (gm)	Shelf life	MRP	Health benefits
1	**Jowar Multigrain Atta**	1000	best before 2 months	47	✚ Rich in fiber, carbohydrates, minerals and vitamins. ✚ Recommended for celiac patients (Gluten free) ✚ Manages and reduces risk of diabetes mellitus (low Glycemic Index, Glycemic Load) ✚ Beneficial for obesity, CVC (bile acid & steroid binding) ✚ Reduces oxidative stress (Antioxidant).
2	**Jowar Flakes**	500	best before 4 months	31	
3	**Jowar Pasta**	80	best before 6 months	18	
4	**Jowar Vermicelli**	180	best before 6	23	

			months		✚ Anti carcinogenic property (phytochemicals, Nitrolosides-antioxidant) ✚ Fights against Arthritis and Rheumatism (Nitrilosides-salicylates) ✚ Low calorie diets (through dietary fiber) ✚ Reduces risk of inflammatory bowel disease (through dietary fiber) ✚ Detoxifying agent (through dietary fiber). Subdues depression (through Mg Presence)
5	**Jowar Upma Rawa**	500	best before 3 months	29	
6	**Jowar Idli Rawa**	500	best before 3 months	30	
7	**Jowar Khichdi Rawa**	500	best before 3 months	30	
8	**Jowar Biscuit**	100	best before 6 months	15	
9	**Jowar Atta**	1000	best before 2 months	50	

1. Jowar rich Multigrain flour

Existing commercialized multigrain atta contain max 5% of jowar but jowar rich multigrain atta contains 50% jowar and the remaining 50% contains wheat, Ragi, Black gram dal, soya and fenugreek seed powder. Different grains have varied advantages, sorghum and other millets add minerals, dietary fiber and nutrients which are otherwise inadequate in normal roti made from wheat. It meets the emerging nutritional needs of the people in the wake of preference for modern and healthy food habits for mass feeding and social programme.

Advantages:

- Overcomes aminoacid balance and inconvinience in roti making.
- Nutritious recipe compared to other existing maket products.
- Free of rancidity, off flavours and off-odours;
- The colour, flavour (whether natural or induced by processing), and particle size of the flour shall be of a proportion not noticeable in the product; and
- Practically free from any living insects and foreign matter.

2. Jowar Flakes:

This technology relates to a process for preparation of convenient, ready-to-eat product from grain sorghum in the form of flakes. The improvement from existing technology of the inventive steps involved in preparation of flakes from sorghum lies in the simplicity of the unit area operations which can be conveniently carried out at household level to industrial, utilizing in variety of sorghum irrespective of chemical composition, agro climatic conditions of cultivation. Flakes eating quality of this technology is much better than existing where sand may adhere to grains during roasting

Advantages:

- Glycemic index of jowar flakes is low and it indicates that jowar flakes are desirable product for diabetes, obese and other life style diseases.
- Jowar flakes are Ready-to-Eat products; thus minimizes the recipe preparation time besides promotes health.
- Jowar Flakes can be consumed as breakfast cereal to both traditional and non-traditional consumers across the country.
- It is nutritional and can be better promoted as health foods compared to other cereal foods.

3. Pure Jowar Biscuits

The technology for the preparation of pure jowar biscuits has been developed by DSR using jowar flour, sugar and fat as main ingredients. Pure jowar biscuits are free from gluten and trans fats. The process of preparing biscuits is simple, includes creaming of fat and sugar, mixing of flour with cream, cutting into cookie shape and baking.

Advantages:

- Have an acceptable flavor typical of well baked biscuits of the type
- Free from any soapy or bitter after taste and
- Free from fungal and insect infestation, rancid taste and odour
- Sorghum biscuits are crisp, and have a taste and color, which is diabetic friendly.
- 4 months of shelf life, subject to proper transport and storage conditions without any deterioration.

4. Jowar Rawa (Coarse, medium and fine)

Sorghum rawa is made through milling technology. Milling is a process of separating the bran and germ from the starchy endosperm so that the endosperm can be ground in to medium size rawa in a hammer mill. Sorghum flour is grinded in a hammer mill through rotating blades which grind the grains in a grinding chamber and pass it through a screen which separates the rawa from the flour, larger, ungrounded particles. As the blades rotate, the rawa is carried through the screen by the airflow through the mill.

Advantages

- Excellent source of complex carbohydrates, protein, fibre, calcium, iron, zinc and magnesium.
- Rich source of phyto chemicals including tannins, phenolic acids, anthocyanins, phytosterols and policosanols.
- Free from “gluten”, Suitable for celiac patients.
- Low glycemic index food, suits better for diabetes, obese, hypertensive and CVD patients.

- No added preservatives

5. Sorghum vermicelli

Vermicelli, popular instant snack food has been used from centuries in Indian culinary to prepare traditional sweets and savories which is prepared from wheat/ refined wheat flour. Vermicelli is liked by people from all walks of life, irrespective of age. With changing lifestyles, preference for instant food items has made vermicelli very popular and an item of mass consumption. Although many snack foods are prepared from coarse cereals, sorghum vermicelli is not yet made. Jowar vermicelli can be prepared through extrusion process to prepare traditional sweets and savories in lieu of wheat/ refined wheat flour vermicelli to obtain nutritional benefits.

Sorghum anad wheat semolina are mixed with 25% to 30% of water in a mixer for about half an hour and dough is prepared. This dough is passed through extruder and long rods of vermicelli are formed which are then cut into desired length and then placed in the tray drier for drying. Drying temperature is around 55-65^{0}C and time required is 4½ to 5 hours. Dried pieces are weighed and packed in polythene bags. The output of the product is 100%. With the addition of milk or vegetables pulp while preparing dough, it adds more nutritive value to the product.

Advantages

- It is an ideal meal for people who pay more attention to their dietary intake.
- Sorghum vermicelli is one of the convinient product in terms of easy preparation.
- It is rich in protein, calcium, iron and magnesium compared to wheat vermicelli
- It is suitable for all age groups.

6. Sorghum Pasta

All over the world, several ready to eat cereal products are being prepared for human consumption. These products enjoy wide popularity among consumers of all age groups. 'Pasta' is the one among them and is prepared from wheat semolina. The availability of advance technology made feasible to producing commercial products out of sorghum. Currently, wheat pasta only is available in the market; Sorghum pasta is prepared with sorghum and wheat semolina. Lack of gluten content in sorghum requires minimum percentage of wheat for texture maintaining in pasta technology. It is made with sorghum flour/ combinations of sorghum flour and semolina using cold extruder.

Advantages

- It is a convinient product.
- It is rich in protein, calcium, iron and magnesium compared to wheat pasta
- It is suitable for all age groups.

6) Name and address of the firm(s) which has commercialized it:

S. No.	Linkages developed (Name & Address of Organization)	Address
1	M/s Hope Blessing pvt Ltd, Delhi	Delhi
2	ITC (foods) ltd, Bangalore	Bangalore
3	M/s Bhavani S S Industries, Mahal Bagayat	Bijapur, Karnataka
4	M/s Heritage Fresh Ltd	Hyderabad
5	M/s Bhagyanagar Foods	Hyderabad
6	M/s Vegan Enterprises	Hyderabad
7	M/s GUV Foods	Hyderabad
8	M/s Kottaram Foods	Hyderabad
9	M/s Nova Traders	Hyderabad
10	M/s Sri Venkateswara enterprises	Hyderabad
11	M/s Chandurotis	Hyderabad
12	M/s Matheses	Hyderabad
13	M/s Madhava Kalyan Foods Products	Rajahmundry, AP
14	M/s ISA Millets	Hyderabad
15	M/s Fountainhead Foods Private Limited	Secunderabad

7) Area (state(s)/ district(s)) covered:

Hyderabad, Delhi NCR, Pune, Bangalore, and other towns of Andhra Pradesh

8) Volume/ quantity of Annual production and approximate sale value:

S.No	Source of Revenue	Total amount (Rs)
1	Royalty Fees from Entrepreneurs	2,60,000
2	Counter sale in DSR	5,60,000
3	Consignments of Heritage and ITC retail stores	6,40,000
4	Sale in exhibitions , trade fair etc	3,00,000
	Total Amount	17,60,000

9) Benchmark (existing similar product) and Consumer acceptance, particularly in case of food products:

No such sorghum foods are available in the market.

10) Status of patenting, if patentable, trademark or any other IPR title, if applicable:

Eatrite is a trademark of DSR. Process for patenting is going on .

11) Status of publication and publicity:

Please find enclosed copy- publications

Publicity: Website "Eatrite" and jingles in different languages

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Note: Use separate pro-forma for each technology

Attach photograph(s) relevant to the technology

Pro-forma 3

Details on Rural Entrepreneurships/ Rural Industries Developed

(Page limit: 3 pages/ rural industry)

1. Name of Sub-project: Creation of demand for miller foods through PCs value chain

2. Name of CPI: Dr. Dayakar Rao, DSR

3. Name of Rural Industry with Address:

1. Millet processing units, KVK, Jammikunta, Karimnagar district
2. Indira Priyadarshini Women Welfare Agency (IPWWA), an NGO, Jedcherla, Mahaboobnagar district
3. Millet processing unit, K.V.K Banagana palli, Kurnool, District

4. Contact: Phone and E-mail of rural industry

5. Investment (Rs.):

6. Product(s) produced and marketed: Sorghum multigrain flour, semolina and muruku (Snack)

7. Annual Production (kg or litre):

1. 150 kgs/ week of Multigrain atta, nearly 100 kgs of Jowar rava
2. 25kg of snacks (muruku)/ week

8. Raw Material(s) and Quantity Used/Year (kg or litre):

9. Cost of raw material (per kg or litre):

10. Price of Product: In Whole Sale

:In Retail

11. Type of Beneficiaries: NGOs, Women groups, farmers.

12. No. of Beneficiaries: 300

13. How the Industry is beneficial to Primary Producers: Self-employment/empowerment to the women, employment during the off season to the farmers.

14. Estimate Employment Generation/Year (person days): 4 human labor required per day for operating the processing

15. CPI to explain whether the industry is approved by FPO/BIS or any other statutory body and how the food safety and quality assurance of end product are being ensured?

Note: 1. Use separate sheet for each rural industry and product.

2. Attach photograph of each rural industry and product.

Millet processing units' establishments

Three self-help groups were identified in three different places viz., KVK, Jammikunta, Karimnagar district. Indira Priyadarshini Women Welfare Agency (IPWWA) an NGO at Jedcherla, Mahaboobnagar district and K.V.K Banaganapalli and supported either with or without the machinery supply from NAIP.

a) *KVK, Jammikunta, Karimnagar district*: The unit is being run by 8 member team of Self-help group. The primary processing equipment dehuller, pulvarizer, and snack making equipment were provided from NAIP .The unit is producing more than 150 kgs/ week of Multigrain atta, nearly 100 kgs of Jowar rawa and catering to the needs of the local people and they have started showcasing in khadi Bandar also. The group is locally supervised by SMS of KVK, who is a home scientist.

b) *Indira Priyadarshini Women Welfare Agency (IPWWA):* The unit started with 5 member self-help group. The primary processing equipment dehuller, pulvarizer, and snack making quipment were provided from NAIP. The unit produces 100kg of rawa and flour and 25kg of snacks (muruku)/ week for every month. The members participates in all exhibitions like millet festivals, ANGRAU Zonal meetings etc for exhibiting their products.

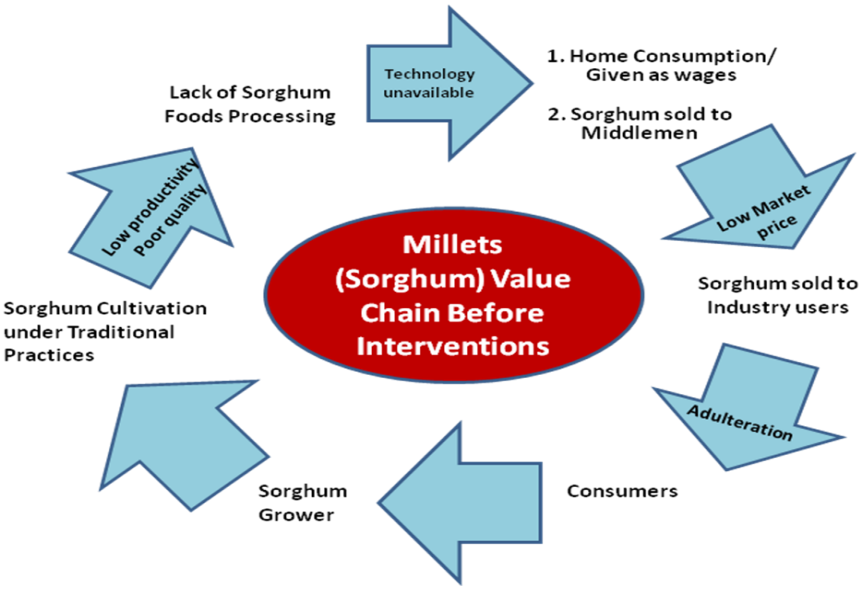
Processing unit at *Indira Priyadarshini Women Welfare Agency (IPWWA)*

c) *KVK Banagana palli, Kurnool District*: The unit started with 5 members of self-help groups. The machinery for the unit was supported by AP Netherlands funds but the after the completion of the project, it was taken over by NAIP and since then it is being given all technical support by the ANGRAU partners. Presently they are producing 13qtls of sorghum rawa and 50kg of muruku per month. They are also supplying these products to Nandi super market and at Shilpa departmental stores at Nandyal

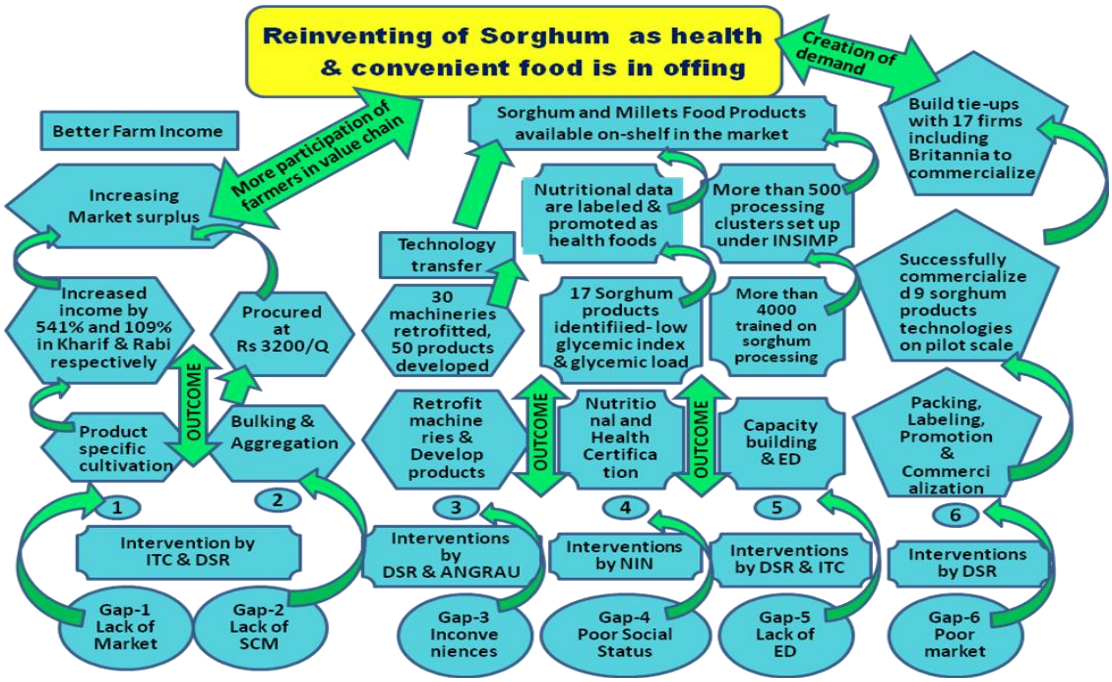
Success story of Intensive end product cultivation (Phule Yashoda) in Rabi sorghum growing district of Maharashtra:

Mr. Rohidas Sawant is a sorghum cultivating farmer in Borisawant village, Parbhani district, Maharashtra. He has been cultivating sorghum since 35 years and he used to cultivate for domestic consumption and for feed purposes. As he is a sanchalak in ITC hub and through hub in-charge, he came to know about the NAIP-MVC project "Creation of demand for millet foods through PCS value-chain" and the on-farm production at Parbhani hub. He decided to take up this as challenge as he wants to create impact in his fields also by acquiring knowledge from scientists. From the day one, he was keen in adopting all practices time to time and kept consulting scientists over phone and personally. He adopted all the practices and overseas that all other selected farmers in his village follow sued. Finally he achieved a big success and received higher yields at a little extra effort. He achieved 52.5 qtl/ha of grain and became the model of other participating farmers. Nearly 30% growth in yields is noticed and the quality of the grain is really good. The buy-back assurance promised at the time of inauguration was fulfilled by the concerned people and he sold 1 tonnes of grain to ITC with a price of 1150/qtl., which is normally good price at farm level. Never he offered this much price nor the procurement was done earlier. He asserted that the bulletin on "Packages of practices for improved rabi sorghum cultivation (Marathi)", which was distributed at the time of launching workshop and advices of DSR scientists at various stages of crop have helped in getting higher yields. He further pointed that with the help of scientists from DSR everything will be possible in sorghum cultivation and he assured to extend his support in future also in the same way. Some of the other participating farmers in Chatouri village also received 45qtl/ha for CSV216R improved variety. The experiences of these success farmers, views and suggestion were recorded for the further effective implementation of project.

Millets Value Chain before intervention



Millets Value Chain actually implemented



A flow chart of the millets value chain as given in the approved project proposal.