Plant Archives **Vol. 25, Special Issue (ICTPAIRS-JAU, Junagadh) Jan. 2025 pp. 69-75**
e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives
Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.SP.ICTPAIRS-013

PRODUCTION, PROCESSING, AND MARKETING OF SORGHUM IN INDIA

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ABSTRACT

The study provides an analysis of the production, processing, and marketing of sorghum (Sorghum bicolor) in India. Sorghum, known for its drought resistance, is a vital crop for food security in semi-arid regions and is widely grown in states like Maharashtra, Gujarat, and Karnataka. The crop's versatility extends to its use in food, livestock feed, and biofuel production. This seminar discusses various stages of production, focusing on cultivation practices, input costs, and challenges such as biotic and abiotic stresses, including drought and pests. The processing section covers methods like cleaning, grading, hulling, and milling, and highlights value-added products such as sorghum flour, snacks, and beverages. Nutritionally, sorghum is gluten-free and rich in fiber and antioxidants, making it a popular choice for health-conscious consumers. The marketing analysis explores key channels through which sorghum is sold, ranging from direct producer-to-consumer sales to more complex networks involving wholesalers and retailers. Price spreads and marketing efficiency across these channels are discussed, identifying opportunities for improvement. A SWOT analysis highlights the crop's strengths, including its adaptability and health benefits, while identifying challenges such as limited market awareness and complex processing needs. The study concludes with recommendations for enhancing sorghum's role in India's agricultural economy through improved infrastructure, marketing strategies, and farmer support systems.

Key words: Sorghum, Production, Processing, Value-Added Products, Marketing

Introduction

Sorghum is a major cereal crop extensively grown in tropical and subtropical regions of the world, playing a vital role in food security, fodder, and industrial uses. It is a staple for millions of people, particularly in Africa and Asia, where it serves as an essential source of energy and nutrition. Comprising about 70% starch, mainly amylopectin (70-80%), sorghum is a valuable energy source. Globally, the United States leads in sorghum production with 10,988 MT, while India ranks fifth with 5,000 MT. In terms of area and production, sorghum ranks third after rice and wheat. Sorghum is versatile, used in producing biscuits, sugar, alcohol, and as a principal source for alcoholic beverages in many countries.

In somregions, sorghum stalks are even carried as decorations during festivals. Industrially, it is important in biofuel production, particularly ethanol, and is used to create biodegradable materials, contributing to renewable energy solutions. Nutritionally, sorghum is rich in carbohydrates, protein, fiber, vitamins, and minerals, and is gluten-free, making it a valuable food source for many. Additionally, it contains antioxidants, adding to its health benefits (Hariprasanna and Patil, 2015).

The yield and quality of sorghum is affected by a wide array of biotic (pests and diseases) and abiotic stresses (drought and problematic soils). These are shoot fly, stem borer midge and head bug among pests; grain mold (all regions) and anthracnose among diseases and Striga drought (all regions) and problematic soilsdsaline (some parts of India and Middle-East countries) and acidic which together (except saline and acidic soils) cause an estimated total yield loss to the tune of US$ 3032 million (Reddy *et al*., 2019).

Sorghum is also notable for its environmental sustainability. Its cultivation supports soil health, prevents erosion, and enhances soil fertility, making it an excellent

crop for long-term agricultural productivity. Its drought tolerance and efficient water use make it a resilient crop, especially in regions facing water scarcity. This makes sorghum not only a key agricultural product but also an important contributor to sustainable farming practices and environmental conservation (Kazungu *et al*., 2023).

The word "sorghum" was derived from "sorgo," the Italian name for the plant, but it is known by various local names around the world. In India, it is called jowar, cholum, or jonna, while in the Middle East, it is referred to as durra. In the Caribbean, people know it as petit mil, and in Africa, it is also called "kafir corn." In China, it is known by its Chinese name, gaoliang. Sorghum is believed to have originated in tropical Africa. From Africa, sorghum spread to other parts of the world through trade and migration. Sorghum is unique in the sense that it is naturally drought, heat, and insect resistant. It thrives in arid areas, which makes sorghum increasingly important globally. The International Water Management Institute (IWMI) warns that, by the year 2025, 25 % of the world's population will experience severe water scarcity, and drought tolerant crops such as sorghum will be important in meeting the food demands for those people by (Kumari *et al*., 2016). It continues to be a vital crop in many parts of the world, contributing to food security, economic stability, and cultural traditions. Today, sorghum ranks among the top cereal crops globally, with significant production in the United States, India, and Africa, reflecting its enduring importance in global agriculture (Kochhar, 2016).

The paper is based upon past studies and literature reviewed. The major contribution in review came from the data available on Agricultural and Processed Food Products Export Development Authority (APEDA), Directorate of Agriculture (DOA), FAOSTAT, MoA & FW, United States Department of Agriculture (USDA), and studies conducted by Chavan *et al*., (2022), Grover and Kumar (2013), Hariprasanna and Patil (2015), Kazungu *et al.*, (2023), Kochhar (2016), Kumari *et al*., (2016), Mounika *et al*., (2020), Sirsat (2024), Ratnavathi (2016), Reddy (2019) and Yadawad *et al.*, (2022).

Production of Sorghum

In Gujarat , it occupied an area of about 0.4 lakh hectares with an annual production of 0.5 lakh tonnes with a productivity of 1378 kg/ha during 2023-24 Oganja *et al.*, (2024). Unfortunately the area of grain sorghum was drastically decreased due to scenario of cash crops in Gujarat, but this situation created a huge potential for fodder sorghum. In Gujarat, Production of sorghum stable over the years. Notably, Tapi consistently shows the highest production numbers, indicating it have favourable conditions for sorghum cultivation. According to DOA (2023), District-wise data on sorghum cultivation in Gujarat from 2019-20 to 2021-22, focusing on the area (A), production (P), and yield (Y). Banaskantha district consistently shows a high area under cultivation, with an average area of 65.45 thousand hectares and a yield of 991 kg/ha over the three years. Tapi district stands out with the highest average production (184.1 thousand metric tons) and yield (2032 kg/ha), making it the leading district in both aspects. On the other hand, Anand, Amreli, and Patan have minimal or no significant production during most of the period. The statewide average for Gujarat is 442 thousand hectares of area, 606.9 thousand metric tons of production, and a yield of 1371 kg/ha, highlighting the overall productivity of sorghum in the state, with significant regional variations across districts.

According to the USDA, (2021), the USA leads as the largest producer, contributing 20% of the world's total sorghum output. Following the USA are Nigeria, Brazil, and India. India accounts for 9% of global sorghum production, making it a significant contributor to the global market. Nigeria ranks as the second-largest sorghum producer, with Sudan, Brazil, and Mexico also playing important roles in global sorghum cultivation. This data underscores the USA's dominance in sorghum production, with other countries, particularly in Africa and South America, also contributing substantially to the global supply. According to APEDA, (2023), Production of millet is varies year by year because of variation in area year by year and farmers are not follow proper agronomic package of practices for cultivation of millet in India. During 2020 millet production is higher with 18.02 (Mn MT). According to APEDA, (2023), Area under sorghum varies year by year because changes in market demand and prices, weather and climate conditions, government policies and technological advancements. During 2017-18 sorghum cultivation area is higher with around 50.24 lakh hactor.

According to APEDA, (2023), sorghum production in India has remained relatively stable, hovering around 47-48 lakh tonnes annually, except for a notable decline in 2018-19. This drop in production during 2018-19 is attributed to a combination of factors such as adverse weather conditions, pest infestations, and potential policy changes that negatively impacted yields. Despite this dip, sorghum production has generally maintained consistent levels over the years, reflecting the crop's resilience and the efforts of Indian farmers to manage environmental and market challenges. According to APEDA, 2023 while Ethiopia and India have shown significant export strength,

Table 1. Cost of cultivation for sorghum Seed and Grain Production.

S. No	Particulars	Seed Production Size Group				Grain Producer
		Small	Medium	Large	Overall	
1	Hired labour	14788	14884	174857	15719	13023
2	Bullock power	3194	2025	2394	2538	3830
3	Machine power	11766	11780	11290	11612	6661
4	Seed	703	684	671	686	392
5	Manure	9955	7718	6539	7837	5904
6	Fertilizer cost	3832	4233	4098	4054	3746
7	Irrigation	2381	1991	1953	2108	2093
8	Repairs	963	927	889	227	821
9	Working Capital	50	50	50	50	0
10	Inerest on W.C	1036	739	287	687	596
11	Repairs	1385	5930	389	901	1345
12	Working capital(1-12)	49358	45966	46049	47124	38415
13	Interest on W.C	2961	2758	2762	2827	2304
14	Depreciation charge	4308	4551	1953	3604	6018
15	Land revenue	181	180	181	181	180
16	Cost A(1215)	56809	53457	50947	53737	46920
17	Rental value of land	50572	46295	47089	47985	21912
18	Interest on fixed capital	6165	5141	3762	5023	5121
19	Cost B (19+22)	133546	104894	101799	106747	73954
20	Family labour	5224	3137	1218	3193	4891
21	Cost C (19+20)	118770	108032	103018	109940	78845
22	Gross Income	304519	278860	283628	289002	132562
	A) Main producer	231488	207179	215890	218186	85288
	B) By- producer	73030	71680	67738	70816	47334
	Cost C net of by- producer	45740	36352	35280	39124	31511
	B: C ratio	2.56	2.58	2.75	2.63	1.68
	Per quintal Cost	1253	1108	1025	1131	1157

other countries like the USA and Australia maintain stable contributions to the global sorghum market. Data shows notable consistency in sorghum exports by India. The peak in 2017 at 529 USD/MT reflects successful agricultural policies and favourable weather conditions.

According to APEDA, (2023), Maharashtra leads the country in both the area under cultivation and total production of sorghum, underscoring its dominant role in sorghum farming. Karnataka ranks second in terms of the area devoted to sorghum, though its production remains behind Maharashtra. Rajasthan and Uttar Pradesh also contribute significantly to India's sorghum production, ranking after Karnataka. In terms of yield, which measures the productivity of the crop, Andhra Pradesh ranks first, indicating that it achieves the highest sorghum output per unit of area, even though its total cultivation area may be smaller than Maharashtra or Karnataka. This data reflects both regional scale differences and productivity efficiencies in sorghum cultivation across India.

Cost of Cultivation for Sorghum Seed and Grain Production

Cost of cultivation sorghum for both seed and grain production in the Satara district of Maharashtra is shown in Table 1. The study revealed notable differences in the costs and profitability between *rabi* sorghum certified seed production and grain production. The total cost per hectare for *Rabi* sorghum certified seed production was 109,940.62, which was significantly higher compared to 78,845.40 for *rabi* sorghum grain production. Despite the higher cost of producing certified seeds, the study found that it was more profitable. The benefit-cost ratio for certified seed production was 2.63, indicating that for every 1 spent, 2.63 was earned. In contrast, the Bratio for grain production was lower, at 1.68, meaning that every 1 spent generated 1.68 in return (Chavan *et al*., 2022).

Processing of Sorghum

Post Harvest Operation of Sorghum

According to FAOSTAT, (2020), there are five post harvesting operation of sorghum like Harvesting, Threshing, Winnowing, Drying and Storage.

Post-harvest operations for sorghum involve several important steps that ensure the quality of the grain and reduce losses. The first step is *harvesting*, which takes place when the grain is fully mature, indicated by hard, dry grains. This can be done manually using tools like sickles or knives, or mechanically using machines. Harvesting at the right time is crucial to prevent grains from shattering or getting damaged by pests and weather.

Once harvested, the next step is threshing, which separates the grain from the plant material. This can be done manually by beating the harvested stalks or mechanically using threshing machines or combine harvesters, which are faster and more efficient for larger quantities. After threshing, winnowing is used to clean the grains further by removing chaff and debris. This can be done manually by tossing the mixture in the air or with mechanical equipment that efficiently separates the lighter materials.

Drying the sorghum is essential to lower the moisture content, preventing spoilage during storage. This can be achieved through natural sun drying or mechanical drying methods. Once dried to a moisture level of about 12-14%, sorghum is ready for storage. It should be kept in

airtight containers in a cool, dry place to protect against pests and mold.

Primary Processing of Sorghum

To increase the appeal of sorghum, especially in urban markets, primary processing is important. The first step in this process is cleaning, where any debris, stones, or foreign materials are removed, and the sorghum is washed to get rid of dust. After cleaning, grading assesses the quality of the grains based on their size, color, and purity. This helps classify the grains into higher and lower grades, affecting their market value.

Next, hulling removes the outer husk from the grains to access the edible part. This process usually involves soaking the grains and then using mechanical methods to remove the hulls. Following hulling, milling transforms the cleaned and hulled sorghum into flour or meal. Specialized equipment like hammer mills or stone mills is used for this, producing a versatile ingredient suitable for various food applications as noted by Ratnavathi (2016).

Secondary Processing of Sorghum

Secondary processing focuses on making sorghum more usable and nutritious. Cooking sorghum flour involves mixing it with water to create pastes for dishes like porridges or flatbreads. Additionally, blending sorghum flour with other gluten-free flours enhances its baking properties, making it suitable for products like muffins and pancakes.

Fermentation is another important step, where yeast or bacteria are used to ferment sorghum, producing items like sorghum beer or fermented porridges. This process improves the flavor and nutritional value of the products. For storage, packaging sorghum involves using durable, moisture-resistant bags to keep the grain safe from spoilage and pests. Proper labeling and conditions help maintain quality and traceability..

Lastly, effective marketing strategies are crucial for promoting sorghum's benefits. This can include advertising campaigns, product demonstrations, and collaborations with food manufacturers to create sorghum-based products. Online platforms and trade shows are also used to raise awareness and increase demand for sorghum in various market.

Sorghum milling is essential for creating a versatile and nutritious ingredient from the raw grains containers such as silos or bins, equipped with proper ventilation to prevent condensation. Proper labeling and storage conditions are maintained to ensure the quality and traceability of packaged sorghum grain.

Table 2. Channel wise marketing cost incurred by sorghum growers.

S. No	Particular	Channels	
		Channel-I	Channel-II
1	Price received by farmer	3977.27	3997.79
2	Packing charges	58.42	60.01
3	Transport charge	0	95.49
4	Hamali	0	29.33
5	Tolai	0	2.98
6	Commission charges	0	0
7	Other charges	0	8.23
8	Total marketing cost	58.42	196.05

Marketing Channel of Sorghum

A marketing involves channels of distribution among the individuals, organizations, and processes essential for moving goods from their production origin to their final consumption destination Katariya *et al.,* (2016), Sulthana *et al.,* (2019), Vasoya *et al.,* (2024). Marketing sorghum involves promoting its various uses and benefits to target consumers, industries, and markets. Marketing strategies may involve advertising campaigns, product demonstrations, and partnerships with food manufacturers to develop sorghum-based products. Sorghum can market through different marketing channels. Online platforms, social media, and trade shows are also utilized to showcase sorghum's attributes and foster consumer awareness and demand.

Channel 1: Producer - Consumers

Channel 2: Producer - Wholesaler - Retailers - Consumer

Channel wise marketing cost incurred by sorghum growers in Solapur district of Maharashtra is shown in Table 2. The per quintal cost of marketing of *rabi* sorghum of Channel I (Producer- Consumer) and Channel II (Producer- Consumer- Wholesaler- Retailer) were 58.42 and 196.05, respectively. Thus, perquintal cost of marketing was highest in Channel I due to presence of intermediaries in channel II.

Among the marketing costs packaging charges and transportation charges were major items and contributed highest share in total marketing cost. Transport charges contributed maximum charges around 48.71 per cent in Channel II.

The per quintal cost of marketing of rabi sorghum of channel-I (Producer- Consumer) and channel II (Producer- Wholesaler- Retailer- Consumer) were 58.42 and 196.05, respectively. Thus, per quintal cost of marketing was highest in channel II due to presence of intermediaries in channel II (Sirsat, 2024).

Table 3. Price spread in different marketing channels of sorghum.

S. No	Particular	Channels	
		Channel-I	Channel-II
1	Gross price received by the farmer	3977.27	3997.79
i.	Marketing cost	58.42	196.05
ii.	Net price realized	3918.85	3801.74
2	Wholesaler		
i.	Price paid	-	3997.79
ii.	Marketing cost	-	133.45
iii.	Marketing margin	-	160.25
3	Retailer		
i.	Price paid	-	4291.49
ii.	Marketing cost	-	88.84
iii.	Marketing margin	-	140.24
iv.	Price received	-	4520.57
4	Consumer		
i.	Price paid	3977.27	4520.57
ii	Price spread	0	522.78

Price spread in different marketing channel is shown in Table 3. Price spread was null in channel-I (Producer-Consumer), as there were no marketing costs and marketing margins between producer and consumer. Though, the producer share in consumer rupee was highest in channel-I *i.e*. 98.53 per cent compared to channel-II (84.10 %), channel II was most prominent due capacity of marketing large quantity of produce and demand throughout year. The marketing efficiency was maximum for channel-I (68.08) and followed by channel II (6.29). The channel-I was the most efficient channel in marketing of rabi sorghum, as there were no marketing costs and marketing margins between producer and consumer (Mounika *et al*., 2024).

The study has estimated the economics of production, processing and marketing of sorghum for fodder in Punjab. The following three major marketing channels were found for disposal of sorghum fodder the study was conducted by Grover and Kumar (2013).

Channel-I: Producer-Forwarding agent/Commission agent-Dairy owner (ultimate buyer)

Channel-II: Producer-Forwarding agent/Commission agent-Chaff cutter- Dairy owner (ultimate buyer)

Channel-III: Producer - Dairy owner (ultimate buyer)

The study has revealed that only two marketing agencies operate in the study area. In Channel-I (Producer Forwarding agent/Commission agent- Dairy owner (ultimate buyer), the producer's share in consumer's rupee has been found to be 74 per cent, while in Channel-II (Producer-Forwarding agent/Commission agent-Chaff cutter- Dairy owner (ultimate buyer), it is about 70 per cent.

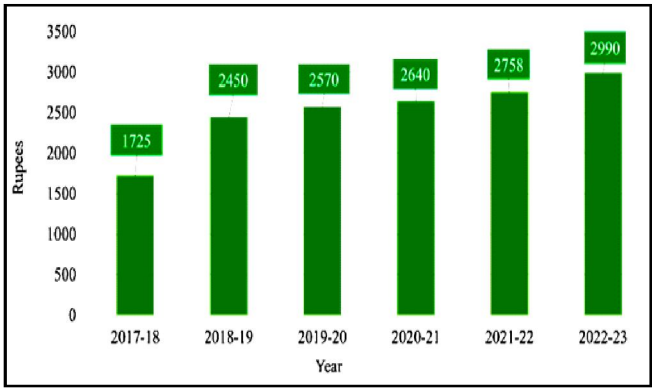

Fig. 1: MSP of Sorghum, 2017-2023.

Channel I: Producer → Consumer

Channel II: Producer → Village merchant/Retailer → Consumer

Channel III: Producer → Commission agent → Wholesaler → Consumer

The study is on marketing cost, marketing margin and price spread in each channel of distribution of Sorghum in Kurnool district of Andhra Pradesh as noted by Maunika and Maurya (2020). It revealed that the through channel-I, the total marketing cost was Rs.63.5/q, total marketing margin Rs.550/q, price spread Rs.680/q, producers share in consumer rupee (%) was 89.54 with a marketing efficiency 9.55. Through channel -II, the total marketing cost was Rs.123.5/q, total marketing margin Rs.1050/q, price spread it revealed that the through channel-I, the total marketing cost was Rs.63.5/q, total marketing margin Rs.550/q, price spread rs.680/q, producers share in consumer rupee (%) was 89.54 with a marketing efficiency 9.55. Through channel-II, the total marketing cost was Rs.123.5/q, total marketing margin Rs.1050/q, price spread. Market efficiency, channel-I was found most efficient over channel-II and channel-III, because there is no anyone middlemen engaged in this marketing channel.

MSP of Sorghum

MSP of sorghum in India from 2017 to 2023 in Rs per quintal is depicted in Fig. 1. According to MoA & FW, 2023, MSP of sorghum is continuously increase year by year because of government initiative and government schemes on different crop to support the farmers. Increasing MSP of sorghum is indirectly beneficial for farmer.

Constraints

Key challenges to agricultural productivity in India encompass the limited availability of improved or hybrid seeds, insufficient seed multiplication capacity, and the low profitability and efficiency associated with the

adoption and use of insecticide, bio-pesticide organic fertilizers, fertilizers, bio-fertilizers, and plant growth regulators. These issues are exacerbated by the absence of complementary improved practices Ghangale *et al.*, (2018), Sathish *et al.*, (2019), Sathish *et al.*, (2022), Kumar *et al.*, (2024a), Kumar *et al.*, (2024b), Pithiya *et al.*, (2024). Yadawad and his co-worker study in Vijayapura district of Karnataka to analyse the constraints for production and marketing of sorghum. The present study was conducted in Vijayapura district of Karnataka to analyse the constraints in adoption of improved rabi sorghum variety (CSV29R) in comparison with local check (M35-1) variety. The results revealed that, on availability of labour during peak period was the major problem followed by non -availability of required quantity of Farm Yard Manure (FYM) and other in production and less remunerative price for produce followed by high price fluctuation and other were constraints in marketing and lack of knowledge on location specific improved varieties of sorghum was major constraint followed by unable to contact extension agencies at the time of necessity and others such as managerial constraint as a noted by Yadawad *et al.*, (2022). The study was undertaken to identify the constraints faced by the farmers in sorghum cultivation. In Gurugram district Haryana Main constraints faced by the farmers in adoption of the recommended package of practices of sorghum are described. For better interpretation and analysis, all the constraints faced by farmers were classified into three categories *i.e.* related to inputs, constraints related to marketing and constraints related to production (Singh *et al.*, 2021).

Conclusion

Sorghum (*Sorghum bicolor*) is a major cereal crop, being grown extensively in tropical and subtropical regions of the world. Sorghum is also valuable feed for livestock and feedstock for biofuel production. Sorghum cultivation is distributed throughout the world. In Asia, it is grown in China, India, Korea, Pakistan, Thailand, Yemen, Australia and USA. India is occupying 47 lakh ha area of sorghum. The major sorghum producing Indian states are Gujarat, Tamil Nadu, Uttarakhand and West Bengal during 2022. Sorghum stalks and by-products are used in various industrial applications and deep root system makes it useful for improving soil health and preventing erosion, particularly in arid and semi-arid regions. In Gujarat, it occupied an area of about 4.46 lakh hectares with an annual production of 6.06 lakh metric tons with a productivity of 1371 kg/ha during 2021-22. Indian sorghum farmers faces many challenges like, The most significant constraint is the non-availability of labour and less remunerative price for produce.

Acknowledgement

I would like to express my sincere gratitude to the Post Graduate Institute of Agribusiness, JAU, Junagadh for their valuable support and resources, which greatly contributed to the completion of this review paper. Their guidance and encouragement have been instrumental in shaping this work. I would also like to express my heartfelt gratitude to my guide, Dr. J.D. Bhatt, for his invaluable support and guidance throughout the preparation of this review paper.

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