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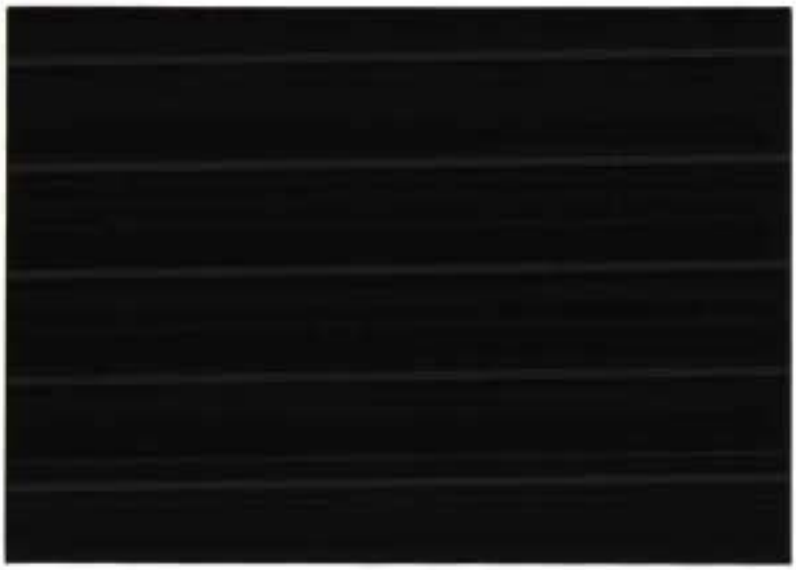

NRI
Natural Resources Institute

Overseas Development Administration

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Report on visits to India and Kenya to appraise past achievements and current initiatives for the post-harvest utilisation of sorghum and the millets

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CONTENTS

LIST OF ABBREVIATIONS

APAU	Andhra Pradesh Agricultural University, encompassing the College of Home Science and the Faculty of Home Science
APDC	Agro Product Development Centre
CFTRI	Central Food Technology Research Institute
HYV's	High Yielding Varieties
ICRISAT	International Centre for Research in the Semi-Arid Tropics
IDRC	International Development Research Centre
KIRDI	Kenya Industrial Research and Development Institute
NGO	Non-Government Organisation
NRCS	National Research Centre for Sorghum
NRRD	Natural Resources Research Department
NRI	Natural Resources Institute
ODA	Overseas Development Administration
OFAR	On-farm Adaptive Research

SUMMARY

This assignment was undertaken to investigate current developments and future potential for post-harvest utilisation of sorghum and the millets in selected states in India. The team examined both food and industrial uses of these products, with a view to the identification of system components for potential transfer elsewhere.

With respect to Kenya, the implementation of results from collaborative projects between NRI/IDRC and the Kenyan Industrial Research and Development Institute (KIRDI) was reviewed as an important indicator of possibilities for the introduction of new, sorghum/millet-based foods in southern Africa.

The assignment formed one component of NRRD-funded projects (A0135 and A0162) entitled 'Improvements to the processing of millets' and 'Improvements to the milling of sorghum: new foods' respectively.

The methodology followed in India comprised in-depth interviews with scientists in leading institutes, observation and inspection of current research and development facilities, field trips to processing operations and markets, and coordination with Government statistical agencies to access market data and literature reviews.

In Kenya, the approach followed included visits to local markets and retail outlets together with in-depth discussion at KIRDI with subject matter experts.

With respect to small grains production in India, an adequate marketable surplus of grains is available, in the short to medium term, for increased primary and secondary processing through a relatively efficient marketing system. The relevant prices for sorghum and millets compare unfavourably with other cereals such as wheat and rice,

partly due to Government policy and partly due to the poor image of small grains as inferior foods, mostly consumed by the poorer socio-economic groups.

Sorghum and the millets have a comparative advantage in low rainfall areas giving them an assured future, albeit with a projected reduced area under cultivation. Varietal improvements are expected to continue to gradually increase yields and production.

Primary processing relies mainly on abrasive techniques characteristically using small-scale, customised milling producing a wholemeal flour for household use. Traditional methods of manual processing are declining rapidly. NRI concept development and experiences in sorghum de-hulling using re-machinable profile surfaces could be particularly relevant in the Indian context.

Secondary processing is at a surprisingly early stage with some limited progress in the area of bakery, snack, weaning and diabetic foods. NRI findings in the scaling-up of semi-wet milling as an industrial process and comparative sorghum milling trials to produce high quality flours were of considerable interest to Indian entrepreneurs.

Existing research and development work has shown particular promise in the areas of malting, popping, bakery products, flaking and extrusion. Promising developments for industrial use include starch, alcohol and sugar which have reached a stage where effective technology transfer is urgently needed. Development of an effective framework for such transfer remains elusive and is considered a significant problem.

The report concludes that considerable untapped potential exists for utilisation of sorghum and the millets both for food and industrial uses. The growing importance of fodder (as a by-product) was noted.

The realisation of this potential would be helped by more coordination and dissemination of research and development results, including those on consumer acceptability, marketing and distribution, prototype developments, varietal selection, novel food processes and, most importantly, effective technology transfer systems.

The report examines the opportunity for technology transfer between India and Africa and for transfer of ideas on marketing systems.

The report makes a number of recommendations with respect to the above, through more research and collaboration between institutes and by targeting support on key bottlenecks identified, for example in marketing distribution and prototype development.

INTRODUCTION

1. This work formed one element of the projects, "Improvements to the processing of sorghum: new foods" and "Improvements to the processing of millets" funded by the NRRD of the Overseas Development Administration (ODA). The key aim of the visit was to ascertain the current status of, and to assess the development potential for, post-harvest utilisation of sorghum and the millets, including:

(i) food uses, both traditional and modern
(ii) industrial uses
(iii)use of by-products, particularly fodder

2. Assessment of potential utilisation includes an identification of constraints and opportunities which govern the realisation of this potential. These include technological, socio-economic, marketing and distribution, and geographical aspects and also technology transfer issues.

3. The technological aspects include key processing technologies necessary for efficient and effective utilisation. These cover mainly dehulling, milling, flaking, popping, malting and alcohol and starch production.

4. Social aspects include, firstly, a general review of changes in society and consumer demand which affect the type and quality of food and other products demanded, especially issues of taste, authenticity and health benefits.

5. Marketing economics and distribution provide a review of prices, production, quality, availability and promotion which combine to satisfy consumer preferences.

6. Geographical aspects, considered briefly, provide a framework for understanding the natural competitive

advantage of sorghum and millet for certain areas with low and variable rainfall.

7. Lastly, but most importantly, is the transfer of the appropriate technology and know-how to the rural and semi-urban entrepreneur at the micro or household level and to small-scale rural industry.

8. The scope of the report is limited to sorghum and the millets, based on the Indian and Kenyan experiences. These grains may be considered as the last frontiers for the development and transfer of appropriate primary and secondary processing technologies and skills. The benefits of successful development programmes would accrue, in this case, to the poorer sections of society who have so far been by-passed by the green revolution which has occurred in other areas of agriculture.

Terms of reference

9. Terms of reference for the assignment are outlined below:

(a) To carry out a three week visit to the main sorghum and millet producing states in India (*viz* Karnataka, Andhra Pradesh and Maharashtra); and hold discussions with selected local organisations to appraise past, current and future developments with these cereals.

(b) To collect baseline data on the nature and extent of current production and marketing of sorghum and millet products, together with indications of their respective financial viability(s); to undertake limited market studies on the products, collecting *inter-alia*, price data on raw materials and processed product/by-products.

(c) Based on introductions from collaborating organisations: To visit two rural/urban and two household

level market-oriented sorghum/millet processing operations for the purpose of reviewing the potential for development of food products, and utilisation of by-products. Processing techniques observed should be detailed and processing constraints and opportunities highlighted.

(d) On the basis of information collected to assess the potential for R&D collaboration with selected organisations in India (*viz* Research Institutes, and/or Non-government Organisations (NGOs).

(e) Following the visit to India, to carry out a two-three day visit to Kenya for the principal purpose of evaluating previous research project achievements encompassing development of sorghum/millet-based new food products. The review should be set against the background of Kenyan government policy towards development of the sorghum/millets sub-sector in the country. Due regard should be given to process-economics, product marketing strategies and social considerations of relevance to the projects.

Activities

10. The main focus of the visit was directed to India, the largest producer of the two crops. The brief time spent in Kenya was intended to provide a "case history" of new product development projects actually carried out in an African context, and in so doing provide clear lessons for the future.

11. The team spent a total of three weeks in India, during which discussions were held with leading institutes, NGOs and Government agencies, and two days in Kenya where discussions were held with the Kenya Industrial Research and Development Institute. A detailed itinerary is presented in appendix 1.

12. The broad approach was:

(a) In-depth interviews with leading scientists in the major institutes within key sorghum and millet producing states in India (viz Karnataka, Andhra Pradesh and Maharashtra) and the Kenya Industrial Research and Development Institute (KIRDI), Nairobi;

(b) Observation and inspection of current research facilities, resources for fabricating prototypes and processing modes in key research institutes;

(c) Field trips to household, semi-urban and small-scale rural industry and NGOs to observe the organisation of processing operations, e.g. popping finger millet, snack food products and pearling small millets. Particular emphasis was given to processing costs and product distribution through appropriate marketing channels;

(d) Discussions with Government departments concerned with rural development;

(e) Coordination with Government statistical agencies to access detailed information on marketing systems including marketed surplus, pricing structures, detailed market data and efficiency and constraints on the marketing process;

(f) Study of associated literature, publications and research reports from the above.

Structure of the report

13. This report comprises six major sections:
(i) A synopsis of the current status of the sorghum/millet sub-sector in India, followed by a description of the production and marketing framework within which a successful programme of increased utilisation of sorghum and millet must operate. This includes production trends, yields, prices, location, marketable surplus, processing status and

consumer demand factors. It also provides a taxonomy of end-uses considered in more depth later in the report;

(ii) An examination of the current and developing range of primary and secondary processing methods, identifying constraints and bottle necks where further development work is needed. The constraints include consumer requirements for quality, nutritional implications, wastage and cost-effectiveness;

(iii) A descriptive account of recent innovations in industrial usage of sorghum/millet with indications of financial viability and industry uptake;

(iv) A review of the outcome of previous collaborative projects on new foods development with the Kenya Industrial Research and Development Institute;

(v) A consideration of the problems of transfer of processing technology from research institutes to entrepreneurs with implications for geographical transfer;

(vi) Concluding remarks and appropriate recommendations.

THE SORGHUM/MILLETS COMMODITY SYSTEM IN INDIA

A synopsis of the small grains industry

14. Sorghum and the millets are important coarse and minor cereals: the annual production in India is about 22 million tonnes. Amongst these, sorghum (*jowar*) and pearl millet (*bajra*) form major crops. Other minor millets are finger (*ragi*) and proso millet.

15. Generally these grains are utilised for traditional food preparations after grinding and winnowing. Unleavened pancakes (*roti*) and dumplings (*mudde*) are some of the more

traditional foods made. Apart from traditional food preparations (see figure 1) a growing diversity of potential end-uses was noted.

16. A necessary condition for diversified utilisation is the development of cost-effective processing both at the primary and secondary level. The emphasis at one leading institute was reported to be on dry-milling.

17. It was noted that mills exclusively designed for millets had not yet been fully developed. A general purpose mini-grain mill has been developed for the refining of grains such as wheat, maize and sorghum. It was reported that a prototype dedicated to cost-effective processing of sorghum and millet was at the concept stage and hindered by the lack of resources.

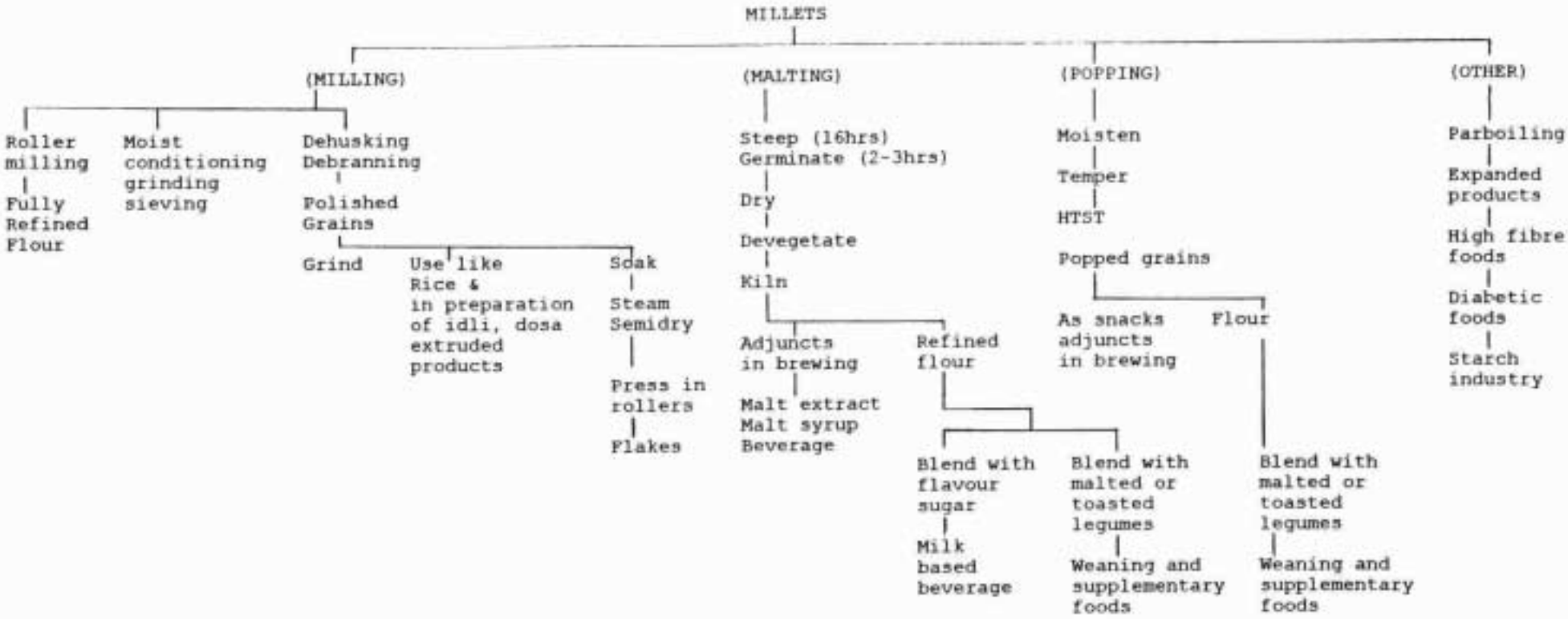
18. Certainly the development of cost-effective dehulling and milling technology, specifically designed for sorghum and the millets and capable of producing high quality flour, was generally regarded as an essential basis for new product development work.

19. Considerable success in research and development in such areas as pearling, flaking, popping, malting and extrusion has been achieved at the Central Food Technology Research Institute (CFTRI), but most of this promising work was at a development stage and needs further R&D for full commercialisation and technology transfer to rural entrepreneurs.

20. In contrast it was reported to us that at the Agro Product Development Centre (APDC), Akola, work on starch, alcohol and other industrial uses were at a commercialisation stage with some technology transfer commencing. The main problem area was the lack of an effective framework and policy for large-scale transfer and utilisation by small-scale rural industry.

Figure 1: Processing of Small Millets for Food and Industry

(Source: Malleshi N G, Central Food and Technological Research Institute, Mysore).



21. In all cases there was a clear awareness of the growing importance of the concept of grain quality linked with diversified end uses. This contrasted with less importance given to grain quality in traditional uses.

22. The emphasis on functional quality implies the selection and development of suitable cultivars with required processing characteristics, as well as cost-effective processing methods and machinery. A match is needed between technologies and the appropriate required quality of the end product.

23. Considerable work on this area has been done and reported in academic publications. What appears to be a problem area is the lack of a practical, systematic and coordinated system for selection of appropriate varieties across a wide range of primary and secondary end-uses.

24. The new policy at the International Centre for Research in the Semi-Arid Tropics (ICRISAT) of on-farm adaptive research (OFAR) stresses varietal selection for maximising on-farm productivity using diagnostic links between farmers and breeders with delineated ecological conditions. This notable advance means less relative emphasis on varietal selection for functional food quality in primary and secondary processing. Given ICRISAT's crucial role this change is important to note.

25. In summary, this preliminary section has identified broad areas where problems exist which, if defined and solved, can increase utilisation of sorghum and millet in India, viz:

(i) Efficient and effective systems for varietal selection for functional end-use quality;

(ii) Improved primary and secondary processing through cost-effective milling machinery dedicated to coarse grains; (iii) Effective transfer of technology and know-how of marketing, consumer preferences and distribution relevant to commercialisation.

Production, marketing and processing

26. This section firstly describes and analyses the agricultural production trends for sorghum and millet in the context of overall cropping patterns in India. This includes details on yields and production over time. The importance of the agricultural base is critical in understanding the potential for primary and secondary processing.

27. Secondly, the marketing system for sorghum and millet is described and analysed including consideration of key aspects such as marketed surplus, marketing channels, pricing and market data. The data are mostly from limited market studies of Karnataka and Maharashtra.

Production trends

28. Table 1 looks specifically at the historical national picture for the major coarse grain, sorghum (*jowar*). The trend shows a recent decline in the area under cultivation offset by increases in yield, giving a slight long term increase in production. The extent of irrigation is minimal, between 4-5%. The extreme variability in yields should be noted, reflected in yearly fluctuations in production.

29. Table 2 focuses on national area, production and yield of pearl millet (*bajra*). The broad trends to be observed are relative stability in the area under cultivation with long term gradual increases in yields and production. The area under irrigation is around 6%. Again it should be

noted that there are considerable year to year fluctuations in yield and production with area remaining fairly constant unlike the overall trend for coarse cereals.

30. Tables 3 and 4 show the statewise area, production and yield of sorghum and pearl millet and indicate the leading states to be Maharashtra, Karnataka, Madhya Pradesh and Andhra Pradesh in the case of sorghum, whereas for millet, Rajasthan, Maharashtra, Gujarat and Uttar Pradesh are dominant. Again the variability in yields between states should be noted

31. In India, sorghum and millets are cultivated in two distinct seasons, the *Kharif* or rainy, and post-rainy or *Rabi*. Almost all *Kharif* and about 90% of *Rabi* is grown under rain-fed conditions and it is important to note that productivity and area changes over time tend to be different between the two seasons. *Kharif* yields for sorghum are rising much faster than *Rabi* yields and there is a slight decline in the trend of area under production for *Kharif* in contrast to stable or slightly increasing area under *Rabi* sorghum.

32. The main reason given for the increases in yields of *Kharif* sorghum, according to ICRISAT research, has been the introduction and spread of hybrids and improved varieties through the 1970's and 1980's, with average productivity increases of 2.7% per year occurring particularly in the more favourable environments where modern cultivars were better adapted and hence more widely adopted.

Table 1: All-India Area, Production and Yield of Sorghum (Jowar)

Year	Area (M. Hects)	Production (M. Tonnes)	Yield (Kgs/Hect)	% Coverage under Irrigation
1949-50	15.51	5.87	378	3.4
1950-51	15.57	5.50	353	3.0
1951-52	15.94	6.08	381	3.5
1952-53	17.54	7.36	420	3.1
1953-54	17.76	8.08	455	3.1
1954-55	17.46	9.20	527	3.3
1955-56	17.36	6.73	387	3.6
1956-57	16.24	7.33	451	3.4
1957-58	17.31	8.64	499	3.5
1958-59	17.96	9.03	503	3.5
1959-60	17.71	8.58	484	3.6
1960-61	18.41	9.81	533	3.6
1961-62	18.25	8.03	440	3.7
1962-63	18.41	9.75	529	3.7
1963-64	18.38	9.20	501	3.9
1964-65	18.06	9.68	536	3.8
1965-66	17.68	7.58	429	4.1
1966-67	18.05	9.22	511	4.0
1967-68	18.42	10.05	545	3.9
1968-69	18.73	9.80	523	4.5
1969-70	18.61	9.72	522	4.1
1970-71	17.37	8.11	466	3.6
1971-72	16.78	7.72	460	4.4
1972-73	15.51	6.97	449	3.3
1973-74	16.72	9.10	544	4.0
1974-75	16.19	10.41	643	4.6
1975-76	16.09	9.50	591	4.9
1976-77	15.77	10.52	667	5.1
1977-78	16.32	12.06	739	4.9
1978-79	16.15	11.44	708	4.8
1979-80	16.67	11.65	699	4.9
1980-81	15.81	10.43	660	4.7
1981-82	16.60	12.06	727	4.6
1982-83	16.38	10.75	657	4.3
1983-84	16.43	11.92	725	4.1
1984-85	15.94	11.40	715	4.4
1985-86	16.10	10.20	633	4.5
1986-87	15.95	9.19	576	4.9
1987-88	16.00	12.20	762	5.0
1988-89	14.60	10.17	697	5.2
1989-90	14.84	12.90	869	5.3
1990-91	14.36	11.68	814	5.2
1991-92	12.36	8.10	655	
1992-93	13.11	12.96	989	
1993-94				

Table 2: All-India Area, Production and Yield of Millet (Bajra)

Year	Area (M. Hects)	Production (M. Tonnes)	Yield (Kgs/Hect)	% Coverage under Irrigation
1949-50	9.26	2.84	306	5.2
1950-51	9.02	2.60	288	3.4
1951-52	9.52	2.35	246	3.8
1952-53	10.77	3.19	296	3.3
1953-54	12.20	4.55	373	3.1
1954-55	11.37	3.52	310	3.6
1955-56	11.34	3.43	302	3.6
1956-57	11.25	2.87	255	3.1
1957-58	11.17	3.62	324	2.9
1958-59	11.43	3.87	338	3.0
1959-60	10.70	3.49	327	2.5
1960-61	11.47	3.28	286	2.8
1961-62	11.28	3.65	323	2.6
1962-63	10.96	3.96	361	2.7
1963-64	11.10	3.88	349	2.3
1964-65	11.83	4.52	382	2.3
1965-66	11.97	3.75	314	2.8
1966-67	12.24	4.47	365	3.1
1967-68	12.81	5.19	405	3.0
1968-69	12.05	3.80	315	4.1
1969-70	12.49	5.33	426	4.2
1970-71	12.91	8.03	622	4.0
1971-72	11.77	5.32	452	3.7
1972-73	11.82	3.93	333	4.5
1973-74	13.93	7.52	540	4.2
1974-75	11.29	3.27	290	5.5
1975-76	11.57	5.74	496	5.1
1976-77	10.75	5.85	544	4.9
1977-78	11.10	4.73	426	4.4
1978-79	11.39	5.57	489	4.4
1979-80	10.58	3.95	373	5.5
1980-81	11.66	5.34	458	5.5
1981-82	11.78	5.54	470	6.0
1982-83	10.94	5.13	469	6.0
1983-84	11.83	7.72	653	4.8
1984-85	10.62	6.05	569	5.2
1985-86	10.65	3.66	344	5.1
1986-87	11.27	4.51	401	6.0
1987-88	8.71	3.30	378	8.4
1988-89	12.04	7.78	646	5.4
1989-90	10.90	6.65	610	6.3
1990-91	10.48	6.89	658	5.4
1991-92	10.03	4.67	465	
1992-93	10.58	8.72	824	

Table 3: State-Wise Area, Production and Yield of Sorghum (Jowar)

State	1992-93					1991-92					
	Area (M. Hects)	% Of Total Area	Production (M. Tonnes)	% Of Total Production	Yield (Kgs/Hect)	Area (M. Hects)	% Of Total Area	Production (M. Tonnes)	% Of Total Production	Yield (Kgs/Hect)	% Coverage Under Irrigation (1990-91)
Maharashtra	5.92	45.2	6.69	51.6	1129	5.49	44.4	3.39	41.8	618	6.4
Madhya Pradesh	1.38	10.5	1.52	11.7	1100	1.38	11.2	1.01	12.5	730	0.1
Karnataka	2.29	17.5	1.99	15.3	870	2.09	16.9	1.71	21.1	818	7.5
Andhra Pradesh	1.06	8.1	0.84	6.5	790	1.07	8.7	0.67	8.3	624	1.6
Tamil Nadu	0.56	4.3	0.67	5.2	1188	0.51	4.1	0.55	6.8	1080	8.5
Rajasthan	0.78	5.9	0.41	3.2	531	0.71	5.8	0.16	2.0	222	0.3
Uttar Pradesh	0.50	3.8	0.44	3.4	884	0.46	3.7	0.36	4.4	787	1.3
Gujarat	0.45	3.4	0.32	2.5	722	0.51	4.1	0.20	2.5	391	5.7
Others	0.17	1.3	0.08	0.6		0.14	1.1	0.05	0.6		
All-India	13.11	100.0	12.96	100.0	989	12.36	100.0	8.10	100.0	655	5.2

Table 4: State-Wise Area, Production and Yield of Millet (Bajra)

State	1992-93					1991-92					
	Area (M. Hects)	% Of Total Area	Production (M. Tonnes)	% Of Total Production	Yield (Kgs/Hect)	Area (M. Hects)	% Of Total Area	Production (M. Tonnes)	% Of Total Production	Yield (Kgs/Hect)	% Coverage Under Irrigation (1990-91)
Rajasthan	4.99	47.2	2.81	32.2	562	4.60	45.8	1.07	22.9	233	1.7
Gujarat	1.27	12.0	1.65	18.9	1298	1.15	11.5	0.82	17.6	713	11.6
Haryana	0.63	6.0	0.74	8.5	1166	0.57	5.7	0.32	6.9	565	15.4
Maharashtra	1.91	18.0	1.78	20.4	933	1.91	19.0	0.90	19.3	470	3.3
Uttar Pradesh	0.81	7.6	0.97	11.1	1189	0.75	7.5	0.77	16.5	1032	4.6
Tamil Nadu	0.23	2.2	0.25	2.9	1104	0.25	2.5	0.27	5.8	1104	10.9
Karnataka	0.37	3.5	0.24	2.8	631	0.41	4.1	0.23	4.8	550	8.2
Andhra Pradesh	0.16	1.5	0.12	1.4	760	0.19	1.9	0.14	3.0	704	13.4
Madhya Pradesh	0.15	1.4	0.14	1.6	892	0.16	1.6	0.12	2.6	731	
Others	0.06	0.6	0.02	0.2		0.04	0.4	0.03	0.6		
All-India	10.58	100.0	8.72	100.0	824	10.03	100.0	4.67	100.0	465	5.4

33. *Rabi* sorghum yield levels are gradually increasing over time but lag considerably behind *Kharif* because of the more difficult environment within which the crop is grown. The frequency and distribution of post-monsoon rainfalls are highly uncertain, as reflected in low and variable grain yields. The adoption of modern cultivars has therefore been limited but, as few alternative crops can be grown, cultivated area has remained stable.

34. Most of the marketable surplus in sorghum and millet is generated by medium and larger farms, whereas the marginal and smaller farms use their production for subsistence or intra-village trade. It should be borne in mind that the area under cultivation does not fully reflect the importance of small grains to the millions of very small farmers in the semi-arid areas who depend upon them for their staple diets.

35. According to ICRISAT research, the overall marketable surplus, defined as the volumes arriving at the main regional markets, constitutes approximately 50% of total production. This figure was also supported by unpublished research data from the Government of India Price Commission. About one-twelfth of the total production, according to estimates from the above sources, is used in intra-village trade for household processing and consumption.

Variability in yields and production

36. It has been noted by inspection of descriptive data that there is considerable variability in yields and production. Work done at ICRISAT has noted that the variability in yields for sorghum and millets has significantly increased since the 1980's. The main result is that the adoption of HYV's is positively correlated with increased sorghum and millet yield and production variability (see table 5). This is probably due

to the early varieties of hybrids being susceptible to disease. Secondly, yield increases in more favourable environments are reflected in significantly higher variability between different agro-ecological regions than within. The importance of such variability lies in the effects on supply and price in selected markets. This in turn effects primary and secondary processing potential.

Table 5: Variability in Sorghum and Pearl Millet Production in the Pre- and Post-Green Revolution Periods

Crop	Variance (billion tonnes)			Coefficient of variation		
	1956-57 to 1967-68	1968-69 to 1979-80	Percent change	1956-57 to 1967-68	1968-69 to 1979-80	Percent change
Sorghum	28	1107	4000	8	16	100
Pearl Millet	63	1043	1670	11	34	210

Marketing Systems

37. This section includes consideration of marketing processes, infrastructure, key trends and statistics. In accordance with the terms of reference, the market studies concentrate on Karnataka and Maharashtra.

38. In each of the main producing states, important regional markets for grains have been set up by the Government. These handle arrivals in bulk from the rural areas and break down consignments for transit to the smaller urban markets (see Appendix 2 for a historical breakdown of seasonality of arrivals and price/quantity relationships in a typical regional market in Kanataka).

39. Estimates made from various studies indicate an intra village trade of a maximum of 20% of the total production with approximately 50%, on average, for domestic consumption and the balance collected through the marketing chain to be sold in the regional markets.

Karnataka

The role of market intermediaries

40. There are three major types of market intermediaries:

(i) Itinerant Traders

These intermediaries circulate around villages and collect the produce from farmers for sale at nearby weekly markets (shandies). They usually make on the spot payments to farmers in advance of deliveries. Thus, the traditional link is one of short term credit to the farmers. Normally, the traders will pay a lower price than the local ruling price with the former arrived at by deducting a margin of around 15-20%.

(ii) Wholesalers-cum-Commission Agents

The marketing system includes wholesalers who operate either on their own account or who function, in addition, as commission agents. Whereas wholesalers make trading transactions by participating in the price discovery process, the commission agents undertake pricing, storage, packing and other transit activities on behalf of their principals or clients. Commission agents also lend credit to producers at the prevailing market rate. The normal margin of such traders ranges from 5% to 12% depending upon the commodity, its nature and alternate uses.

(iii) Wholesalers

Wholesalers generally conduct bulk trading with a normal profit margin of 5% to 8% over the wholesale price. They link regional markets within and across different states and usually operate by making on the spot cash payments to the itinerant traders.

Storage

41. As small and marginal producers dominate (80 + %) in the Indian agricultural economy, producers do not normally store for marketing. Only enough stocks for personal consumption are commonly held on-farm. The tendency of producers, irrespective of size, to hold stocks for marketing (for sorghum and millet) is very small.

42. On the other hand, traders or commercial millers hold stocks in central warehouses near the regional markets for longer periods of up to 3 months, as these coarse grains store well. Grains are stored in gunny bags (100 kgs) stacked in simple warehouses (godowns) and are occasionally, though rarely, fumigated against occasional problems with insect and/or rodent infestations. Supplies released by traders through the regional markets are broken down into a myriad of small markets where all types of grains can be purchased. Consumers purchase small grains unmilled in small amounts and arrange custom milling to produce flour supplies for a range of 1-7 days, depending on their economic circumstances.

Marketing chains

43. The basic marketing chains for sorghum and millets are indicated as follows:

SORGHUM (JOWAR)

A. Producer > Itinerant Merchant > Wholesaler > Retailer > Consumer (90%)

B. Producer > Wholesaler/Commission Agent > Retailer > Consumer (5%)

Note: Figures in the parentheses indicate proportion of the produce passing through the channel to the total market.

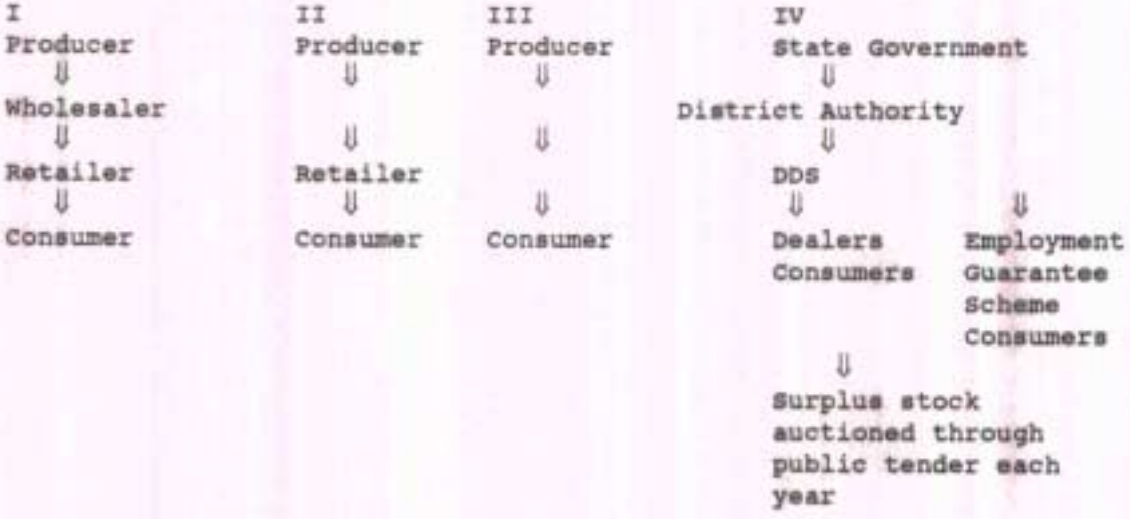
Maharashtra

Role of Traders

44. Producers bring their produce to primary markets through commission agents. Wholesalers purchase the produce and normally pay the commission agent within 7-10 days. Retailers purchase the produce from wholesalers, who usually keep the purchased stock in godowns and hypothecate to the bank, negotiating up to 75% of the cost as cash credit on interest. Credit is released by the bank to the wholesalers against the money deposited for the stock sold to the retailers. Wholesalers and commission agents also borrow money from local banks on interest. Banks give 75% of the total cost of the stock on 18% per annum interest.

Marketing chains

45. The marketing chains in Maharashtra are similar to Karnataka as shown below:



Note: The guaranteed-price procurement scheme has been stopped by the State Government for sorghum and millets this year (1995).

Processing

46. In contrast with processing facilities for other grains, there is no large-scale, commercial milling of sorghum and millets in India. In Karnataka there are a large number of very small processing units dealing strictly on a localised scale, often within a radius of a single day's cart travel. These produce pop-corn which is prepared from sorghum and is very popular with consumers. Fried sorghum, with a hint of salt or spice, adds a taste which consumers, especially children, prefer. The price of unprocessed sorghum per quintal(100 kgs) in the wholesale market averages Rs 400 whereas popcorn sorghum is sold at Rs 1.00 per packet of 50 gms. The value added is thus up to Rs 1600 per quintal

47. In addition to small-scale, customised milling and preparation of food products from sorghum and millet, in Maharashtra, for the last five years, sorghum has been utilised for starch production in units set up for maize processing. Some quantity of sorghum has also been used for alcohol production. Other minor by-products on a very small scale are soap from the germ oil and cosmetic items. Special-purpose grains and flour prepared for religious purposes from minor millets are produced by 16 small scale units in Maharashtra and elsewhere. Both states surveyed are said to produce up to 120,000 tonnes per year of these products. A new product just being launched at the time of the visit was sorghum flour as a health product for diabetic people. This was for large scale production and national distribution.

Marketed Surplus

48. Indicative proportions of marketed sorghum production in the two states are shown below:

Table 6

Marketed Surplus of Jowar (%)

	Maharashtra*	Karnataka**
Production	100	100
On farm consumption***	40	45
Family consumption	28	
Wages in kind	12	
Marketed Surplus	60	55

* Based on a ten year average 1982-92

** Based upon a nine year average 1982-1990

*** May include a small bought-in element.

Sources: Various agencies contacted during the survey.

Price Spreads

49. The table below compares the price spreads for sorghum for both states:

Table 7

Price spread estimates for Jowar in Maharashtra and Karnataka markets in percentages (1982 - 1994)

	Maharashtra	Karnataka
Producer	76	76
Itinerant Merchant	5	4
Marketing margins		
Wholesalers margin	6	9
Retailers margin	13	11
Consumer price	100	100

Sources: Various data sources contacted during the survey.

50. The price spreads and margins are quite comparable with a developed market economy and tend to show that the power of the middle man to earn excessive margins due to a monopolistic position, which existed some 20 years ago, has now been eroded by deregulation of markets. This relative efficiency must contribute to the potential for primary and secondary processing although further studies on this are needed.

Quality and Price Effects

51. In both Maharashtra and Karnataka grain quality has an extremely significant impact upon price, especially colour, appearance, taste, texture and moisture content. It is especially noticeable that hybrid varieties fetch lower prices than the local varieties in the wholesale markets because of organoleptic factors. Limited observations suggest that variability due to quality effects can affect prices in a range from Rs 230 per quintal to Rs 295 per quintal around an average of Rs 250.

Role of Procurement Agencies

52. State governments play an important role in procuring sorghum and millets from poorer farmers and hill tribes. Their purchases are partially disposed of through public auctions which are a major source of supplies for the limited comercial processing which is carried on in Maharashtra. Other supplies are distributed through fair price shops to assist the economically-deprived classes.

53. Two parastal agencies, the Food Corporation of India (FCI) and Karnataka State Food and Civil Supplies Corporation (KFCSC), which are central and state Government undertakings respectively, are engaged in procurement of major cereals such as wheat and rice. KFCSC is also being supported by the

Marketing Federation of Karnataka. Procurement is carried out at the minimum support prices declared by the Government of India for each commodity.

54. Only approximately 10% of sorghum and millet production is procured through official channels so the impact on the market is quite small and small-scale farmers, at times of depressed market conditions, have a guaranteed procurement price which stabilises production. For small grains such as sorghum and bajra, market prices often fall below official procurement prices, unlike the situation with other major crops. In general, the procurement agencies are seen to play a valuable social role in supporting the deprived classes and providing foodstuffs at low prices through fair price shops and auction sales.

55. In conclusion, the Indian system of procurement support prices run by parastatals or privatised agencies could well be transferred to African countries as a means of stabilising key market factors. The price and market system in India consists of a minimum or procurement support price for food grains as shown in Table 8 and actual market prices formed by a free market process in the main regional markets in each state where most bulk deliveries are made. The announced support prices are invariably higher than market prices except in the case of the coarse grains.

56. While nominal prices (not adjusted for inflation) have increased for all crops, real price levels for sorghum have fallen more sharply than for other crops. As ICRISAT research has established, sorghum and millet tends to fetch the lowest market price, a reflection of low consumer demand and the perception among some socio-economic groups that sorghum and millet for human food is an inferior good. In fact, in the

urban areas, these cereals exhibit a negative income elasticity.

Table 8: Procurement/Minimum Support Prices of Foodgrains

(Rs.Per Quintal)

Commmodity	Quality	Year (Crop Year)	Year (Marketing Year)	Price Recommended by the CACP	Price Announced by the Govt.
Coarse Cereals (Jowar, Bajra, Maize & Ragi)	F.A.Q.	1975-76	1975-76	74.00	74.00
		1976-77	1976-77	74.00	74.00
		1977-78	1977-78	74.00	74.00
		1978-79	1978-79	78.00	85.00
		1979-80	1979-80	85.00	95.00
		1980-81	1980-81	97.00	105.00
		1981-82	1981-82	116.00	116.00
		1982-83	1982-83	118.00	118.00
		1983-84	1983-84	124.00	124.00
		1984-85	1984-85	130.00	130.00
		1985-86	1985-86	130.00	130.00
		1986-87	1986-87	132.00	132.00
		1987-88	1987-88	135.00	135.00
		1988-89	1988-89	145.00	145.00
		1989-90	1989-90	155.00	165.00
		1990-91	1990-91	180.00	180.00
		1991-92	1991-92	205.00	205.00
		1992-93	1992-93	225.00	240.00
		1993-94	1993-94	260.00	260.00
		1994-95	1994-95	280.00	325.00

SOURCE: Agricultural Statistics at a Glance by Directorate of Economics and Statistics, Ministry of Agriculture and Cooperative, Ministry of Agriculture, Government of India.

57. It is noticeable that milling of flours from sorghum and millet and sales in retail packs are only just starting in India, with the growth in demand for convenience products by the new, rich, middle classes. In contrast, in Kenya, we observed that combined flours including sorghum and millet were generally available at low prices with also a variety of imported snack food products. In India, with a culture of street foods, a variety of snack food products would be accessed by consumers through local markets.

Marketing of by-products

58. Fodder in India is forming an increasingly important component of the total value of production. The value of the cereal straw is derived from its use in meeting the feed requirements of bullocks and milk animals. Around larger population concentrations, specialised markets have developed due to the strong demand for dairy products. In depth research at ICRISAT, discussed extensively with the team, highlighted the fact that *Rabi* sorghum is prized as much for its fodder as for the grain. This is not to say that *Kharif* fodders are not also of considerable value but they are ranked lower relative to *Rabi*products.

59. Data from Maharashtra and Karnataka has shown that the contribution of fodder to the total value of production ranged between 34 - 59%. Sorghum straw prices have increased faster than inflation, in fact the relative value of sorghum straw to grain has doubled in the last twenty years because of the following factors:

(i) Sorghum straw is the staple diet for draft and milk animals, and

(ii) The derived demand for fodder from increased demand for milk products, in turn derives from higher income levels in the urban areas.

Concluding remarks

60. The evaluation drawn from the qualitative and quantitative information reviewed is that an adequate marketable surplus of sorghum and millet is available, in the short to medium term, to support increased, diversified utilisation. This is despite

the apparent slow increase in yields and production and sharp fluctuations in these from year to year. An efficient, informal and formal distribution system operated by wholesalers and traders, as reported to us, evens out surpluses and deficits in different areas to meet market demand. In addition, supply has proved responsive to increased demand, for example with *Kharif* sorghum. The efficiency of the regional marketing system supported by minimum procurement prices has provided the basic marketable surplus for the urban population for primary processing. Thus, the marketing system at this stage is not a constraint on the potential for further primary and secondary processing, in contrast to the situation reported in the Kenyan study.

61. As the improvement in varieties through ICRISAT's OFAR policy gathers pace, the production base of the food system for sorghum and millets should strengthen. The key problems which could arise in the medium to long-term are as follows:

(i) The need for increased storage facilities for buffer stocks due to increased regional variability in outputs, and greater need for reliability in supply for primary and secondary processing;

(ii) Availability of appropriate varieties in the marketable surplus;

(iii) The development of a more efficient marketing and distribution system for bulking up supplies for industrial utilisation including specific sorting, grading and packaging standards;

(iv) The development of transport infrastructure to support distribution and marketing, which, according to ICRISAT research, is a key constraint;

(v) Improved availability of trade credit to smooth market flucuations.

NEW DEVELOPMENTS IN PRIMARY AND SECONDARY PROCESSING

62. This section considers a range of primary and secondary processing methods at various stages of development in India. The team primarily relied on in-depth interviews with the leading experts in the area, supplemented by direct observation of processing operations. In this way the team aimed to obtain a close view on the ground of the practical progress in utilisation as distinct from solely a review of the academic literature.

63. Particular factors of relevance were: consumer requirements for high quality; primacy of nutritional factors; and cost-effectiveness.

64. A general trend towards increased health consciousness and convenience by an expanding middle class was also born in mind. The importance of authenticity in food quality derived from cultural factors was a general factor affecting the acceptability of new product developments based on sorghum and millet. It was reported that authenticity in taste and texture were particularly strong in areas where sorghum and millet foods have historically formed the staple diet.

65. Processing machinery needs to fit in to the structure of the food system operating in the coarse grain growing area. Processing at the household and small-scale level is either based on a series of small batches of homogenous grains or else a bulked-up quantity of heterogeneous grains including a range of varietal differences in seed size and hardness. Thus, a capability to deal efficiently with small batches of varying

grain characteristics on a very small scale (often referred to as micro-level) is required.

Primary processing

66. There are many different types of processing of coarse grains but the team found that, in India, processing was predominantly of the abrasive type using characteristically small-scale, customised mills, producing a wholemeal with the grain husks removed by winnowing and used for animal feed. Traditional techniques of manual pounding and grinding are still important but declining.

67. Refined sorghum and millet flours and/or compound flours are simply not available at a commercial level, in stark contrast to the situation in Kenya where blended *uji* flours, comprising maize, sorghum and/or millet meals, are available in all retail outlets and markets at low prices. Very localised availability of sorghum and millet meals was reported and directly observed in both Maharashtra and Andhra Pradesh.

Dehulling

68. The team observed a number of critical developments in processing at various leading institutions. A prototype mini dehuller has been fabricated by the Andhra Pradesh Agricultural University (APAU) in collaboration with a local agricultural engineering company. This work was an element of a larger programme funded by the International Development Research Centre (IDRC) concerned with "Sorghum Food Enterprises for Alternative Uses and Supplementary Feeding".

69. Such dehullers have been successfully installed within a number of small-scale rural enterprises in Andhra Pradesh which produce sorghum-based bakery and snack foods. The products are

distributed within a localised geographic area through a limited number of selected outlets, or as a component of supplementary feeding programmes for pre-school children. It was reported that a few voluntary organisations produce dehulled grain on a commercial scale for sale in the local market.

70. A typical cost profile for a sorghum dehulling unit is shown in Appendix 4. It may be seen that the rate of return on total capital employed is adequate and sufficiently robust in the face of varying changes in input prices.

71. The cost-effective nature of this important but limited innovation in evidenced in the successful adoption of dehullers by small-scale entrepreneurs in Andhra Pradesh, albeit in very limited numbers.

72. Field investigations revealed the perception by key experts that further improvements are required in terms of dehulling performance and improved aspiration giving a higher quality and quantity of final yield. It was felt at APAU, as at CFTRI, that a specifically-designed machine for millets, locally fabricated at low cost, was required. Such a unit should be appropriate for many of the minor millets grown in certain rural and tribal areas. The importance of identifying suitable varieties of such millets for dehulling was again emphasised.

73. Work undertaken by APAU has revealed some socio-economic constraints at the village level, particularly the shift in economic power from women, and secondly the perception that dehulling involves an unacceptable loss of nutrients. It was reported that there was no shortage of would-be entrepreneurs for this proposed programme.

74. The importance of mini or micro-level scale of machinery which is needed to fit into the constraints of the local food system was noted, especially for the rural and semi-urban areas. In contrast, small-scale production is usually a commercialised undertaking using hired labour located in industrial areas.

Milling: the Mini Grain Mill

75. The mini grain mill represents a more complex technology in that it carries out all the milling functions, including aspiration, in one pass. The design for the mini coarse grain mill developed by CFTRI is available to users against a nominal fee of Rs.2,000 and can be fabricated locally. Although a considerable number of licensees have taken the designs from CFTRI, milling machines for coarse grains have not been successful and only one is in operation in Tamil Nadu.

76. This low acceptance rate raises questions about the efficiency of the technology, in terms of market requirements and cost, and the effectiveness of the dissemination efforts.

77. Close observation suggested that major drawbacks in technical feasibility stemmed from:

(i) Variability in grain size and hardness for millet varieties, with no milling process specifically designed for efficient utilisation of millets. A simple device for grading grain by size could be beneficial;

(ii) Relatively poor separation of the germ from the endosperm, and;

(iii) Required improved aspiration to remove the husk; small amounts of husk are perceived to indicate a lower quality

product and evidence of contamination to the consumer. Husk removal would significantly improve food acceptability.

78. In summary, alleviation of these technical bottlenecks would lead to: a perception of improved quality and purity of the final product; improved keeping quality; the basis for the successful diversity of product uses, e.g. compound flours for bakery and snack food production.

79. It was emphasised to the team at ICRISAT, the National Research Centre for Sorghum (NRCS), APAU and CFTRI that selection and breeding of varieties with good milling qualities is essential and should include research into important grain characteristics as they relate to milling.

Secondary processing

80. Secondary processing is closely linked with new product development and a wide range of machinery prototype development, much of which is being done at CFTRI. Successful exploratory trials currently underway involve: flaking, popping, supplementary foods, extrusion and noodle development at levels appropriate to small-scale rural industry (see Fig. 1).

81. Basic information on new product development is given in Appendix 3. Some critical points to note are as follows:

(i) *Jowar* flakes; the final product is highly palatable and comparable with rice and wheat flakes but of a lighter texture and highly acceptable to certain market segments. The main bottleneck is the efficiency of the process to reduce costs;

(ii) *Jowar* noodles; these are of high quality and acceptable to the consumer but it should be noted that the process is

still very much laboratory-based and the machine design is still being developed;

(iii) The production of a partially popped and ground finger millet flour is well developed and the product is highly acceptable to a local but limited market. Further technical considerations concern the identification of suitable sorghum and millet varieties and a reduction in present contamination with sand encountered during the processing.

Development of speciality foods

82. As has been noted, the rising concern for health benefits, the awareness of nutrition, particularly in relation to children, and concern for authenticity in organoleptic factors form the framework for promising developments in speciality foods. Evidence was presented (Directorate of Industries, Bombay) of acceptability among substantial socio-economic groupings at all levels in society, spreading out from the traditional sorghum and millet areas.

83. The basis for the health benefit derives from the nature of the starch component as it is broken down in the digestion process. For example, the slower rate of digestibility of finger millet in comparison to sorghum and pearl millet has been demonstrated. The implication is its possible effectiveness for diabetic patients in the control of blood sugar levels.

84. Some significant speciality developments are as follows: Enteral foods for use in a medical context but requiring further development; food for the elderly; malted cereals; and legume-based products with low bulk and high energy density.

85. Other potential health benefits include the hypothesis that the incidence of duodenal ulcer is lower in traditional sorghum and millet consuming areas of India.

86. Further development work is needed in most of the areas highlighted above. Further work is needed, in addition to the surveys already carried out at APAU, to delineate a perception of possible health benefits of these new foods among different market segments.

87. Some existing evidence from surveys in Andhra Pradesh looking at sorghum and millet potential among traditional and non-traditional consumers concluded that:

" - The initial "Core Group" would be those already using sorghum to whom the added value of recipes or varieties make sense in terms of their basic food traditions;

- Communicating nutrition benefits of sorghum would be an important reinforcement for non-users, since they already know that it is generally good for health;

- Recipe development might lead to consumers preferring sorghum for "special dishes or festive dishes" as well, besides snacks or weaning food. It seems reasonable to assume that these in themselves would lend some glamour to sorghum;

- In this marketing situation, a higher price supported by the added value of processing usually has its own glamour. Alternatively "Fair Price" shops could be utilised for the distribution of products."

88. Particular capability and skills in nutrition and food preparation have been demonstrated by APAU in successfully completing the "Sorghum Food Enterprise Project" specified

earlier. This also involved transfer of technology and know-how to the rural community. Stage two of this process, involving large-scale transfer and development, was halted through lack of funding.

INDUSTRIAL USES

89. Industrial uses currently being researched and developed in India are mainly starch, alcohol and sugar production. Other areas under consideration are the extraction of colour from sorghum glumes.

90. Work is well advanced at the Agro Product Development Centre (APDC), Akola University where research capability and transfer to industrial application has been demonstrated. Despite the initial scepticism of the industry, it was reported that six industrial concerns are now manufacturing sorghum starch, albeit that, as a result of the continuing low status of sorghum, the product is sold as maize starch.

91. Such links with industry have come from the individual efforts of Professor Somani as there is no formal mechanism to facilitate the transfer of such technologies.

92. The basic scientific research and support for such work derives from ICRISAT which has a substantial research work record in this area. Some specific industrial applications are as follows:

Supplementary sugar crops, sweet sorghum: the production of liquid glucose

93. Ground whole grains are subjected directly to enzymic hydrolysis, thus by-passing the traditional costly starch

separation process and providing an opportunity for the development of small-scale, independent processing units. Because of the specificity of the enzymes, intermolecular reactions do not occur, thus eliminating the formation of colour bodies or bitter-tasting degradation products. Highly proteinous spent grains are produced as a by-product.

94. The process shows an acceptable level of profitability with the obvious need for cost-reducing changes in processing. The overall demand factors for different types of sugar indicates a buoyant demand for this innovatory process and profitable opportunities for entrepreneurs provided the cost levels can be reduced.

Sorghum starch production and by-products

95. At the commercial level the production of sorghum starch is confined to a few early adopters. The financial and technical advantages, given an effective transfer mechanism, should ensure the continued diffusion of this sorghum-based process. The technology developed to extract starch from maize has been successfully modified for extraction of starch from sorghum.

96. The financial viability derived from a range of individual company studies carried out at APDC indicates an acceptable level of profitability not overly sensitive to changes in input prices. Many of these studies are confidential and carried out for nascent industrial development. A typical example is shown in Appendix 5.

97. There is significant opportunity for increased utilisation of sorghum, particularly in the light of the decline of the tapioca starch industry and the increasing demand for starch and its derivatives. A particular trigger to increased

awareness was the surplus of discoloured grains which could not be fully utilised following the 1993 *Kharif* season and which were exported as blackened grain to Taiwan.

98. In general it was felt at CFTRI and APDC that the major constraint was the continuing scepticism of industrialists and the need for technology transfer channels to industry.

Alcohol production from sweet sorghum stalks

99. Professor Somani reported details of the production of alcohol from sweet sorghum stalks in which there is some industrial involvement, but little information is available on the technical and economic effectiveness in the Indian context. Further work, both technical and economic, needs to be done before an evaluative judgement can be made.

100. In summary, the problems with this process follow a similar pattern to other utilisation problems which indicate the following requirements:

(i) Cost effective machinery which can be fabricated from local materials;

(ii) Some improvement in quality parameters;

(iii)Industrial market research on customer groups to define financial and technical requirements, and;

(iv) Partnerships with industrial entrepreneurs to encourage early adoption and diffusion.

Other industrial uses

101. Additional possibilities for diversified utilisation which have been investigated for industrial uptake have included:

Production of rectified spirit from blackened sorghum
Alcohol production from sorghum grain
Production of sugars from sorghum grain

Diagrammatic representation of a range of industrial processes, together with selected financial analyses of typical commercial enterprises, are shown at Appendix 5.

DEVELOPMENT OF NEW SORGHUM/MILLET-BASED FOODS IN KENYA

Background

102. The visit was undertaken for the principal purpose of evaluating the status of implementation of research findings from the only known, Africa-based, projects in the field of new foods development based on sorghum and millets. These projects had been conducted on a collaborative basis with the Kenya Industrial Research and Development Institute (KIRDI) aiming to develop new products from sorghum of appeal to the urban consumer.

103. A NRI/KIRDI project ran from March 1985 to October 1986 in Kenya with an NRI Technical Cooperation Officer seconded full-time to KIRDI. Project activities followed the development of the following products: pearled sorghum (*supa mtama*); meal from white and red sorghums; instantised or easy-cook meals and flours, enhanced with flavours resulting from malting, toasting and fermentation procedures; pre-cooked items, utilising drum-drying and cooker-extrusion techniques.

104. Considerable work was done with respect to pilot marketing, assessment of demand, design, development, the

organisation of production, evolving brand names and popularising them through promotional efforts, quality control, attractive packaging, operating sales outlets etc. Constraints encountered during the project can be summarised as follows:

(i) Difficulties in obtaining regular supplies of sorghum of acceptable quality; unforeseen difficulties (poor results on the drum dryer; non-availability of a cooker extruder) prevented completion of work on pre-cooked products, and concern regarding mould growth and cyanide toxicity caused delays in malted product development.

(ii) Absence of a full survey of market prospects for *supa mtama* coupled with inadequate organisational efforts; insufficient attention to the market potential for nutritionally-enriched cereal-based products.

(iii) Achievement of ambitious goals not adequately facilitated by the budgetary resources provided.

105. An appraisal mission undertaken in 1986 (Dendy D A V and Farrington J (1986) - Report on a visit to Kenya to evaluate the KIRDI/NRI project on the development of new food products from sorghum) highlighted the following :

"Recommendations are made for tighter project monitoring and management in any future collaboration between NRI and KIRDI. A number of short, discrete projects is proposed, comprising:

(i) Industrialisation of pearled sorghum - to secure commercial up-take of the technology developed in 1985-86,

(ii) Establishment of a testing facility for sorghum breeders - on a regional basis in conjunction with EARSAM/ICRISAT,

(iii) Improvements to pearlers - introduction of design modification to the IDRC dehuller,

(iv) Scale-up of manufacture and marketing of brown and white *uji* meals - to achieve standardisation of colour and particle size,

(v) Pilot production of nutritionally-enhanced *uji* meals - focussing specifically on sorghum as a component in weaning foods,

(vi) Development of cost-effective techniques for the germination of red sorghum and the production of a range of malted and/or instantised products - including orientation visits to countries already producing these,

(vii) Evaluation of the destoner,

(viii) Introduction of semi-wet milling - to obtain improved yield of high-quality flours, and

(ix) Institutional support to KIRDI in economic aspects of new product development."

106. These recommendations were not accepted mainly because of the lack of technology transfer and perceived practical industrial applications. KIRDI proceeded to collaborate with the International Development Research Centre (IDRC).

107. The collaborative project between KIRDI and IDRC ran from 1988 to 1994. The project provided for measures to investigate further the contribution small-scale processing plants, particularly dehulling, could make on the utilisation and production of sorghum grain in Western Kenya. A small-scale processing enterprise was established at Kisumu, an established

sorghum growing area, and the region's biggest administration and industrial centre. Production in the area is mainly small-scale and subsistence level, red and brown varieties. During this period the plant diversified into the processing of finger millet.

108. Provision was also made to monitor the performance of dehullers situated in Kitui and Machakos districts in the Eastern Province. Such dehullers had been made available to the communities within this region from the early 1980's under the Arid and Semi-Arid Lands Development Programme.

109. Whilst undertaking the project the following short-comings in existing Government legislation were highlighted (From: Sorghum Processing Pilot Project, Final Draft Report (1994)):

(i) Lack of promotion efforts to encourage the processing of sorghum and millet crops,

(ii) No legislation and standards for sorghum and millet grain and/or processed products. It is recommended that quality standards should be formulated as a matter of urgency since these products are already in the market,

(iii) Current pricing policy and market regulation.

110. The technology development and transfer efforts of KIRDI described below need to be considered in the light of the above background.

Kisumu Sorghum Pilot Plant

111. Of the major pieces of equipment utilised, the grain dehuller was purchased from Nutana Machine Limited, Canada at a 1988 cost of Canadian dollars (CD)$ 7254.00 (Ksh 110 058.00).

In 1994, this dehuller was found to be "operating inefficiently". The Kisumu plant processing operation commenced in 1991 utilising a dehuller based on the PRL/RIIC machine.

112. The review of the dehuller performance enhances the need for further R&D input, as it "proved to be a problematic piece of equipment which caused several day of stoppage in processing. The pulley was on several occasions loose and wobbly, requiring tightening. The aspiration system was also inefficient. The shaft had been repaired but needed replacing, as did the belts of the pulley. The abrasive grinding stones also required replacement at least once a year."

Progress achieved in production: Trend data

113. Table 9 indicates the total sale of processed products from the Kisumu plant over the period July 1992 to May 1994. The revenue realised from these sales amounted to Ksh2,000,000.00.

Table 9: Sale of processed products from Kisumu Plant: July 92 - May 94 (Sorghum Processing Pilot Project, Final Draft Report (1994)).

Product	Quantity sold (kg)
Brown flour	118,260
White flour	1,596
Supa Mtama	2,083
Finger millet flour	6,717
Composite flour	447
Bran (from sorghum)	7,547

114. A number of major factors affected sales and uptake of products: Competition from maize and wheat; low capacity

utilisation due to breakdown of processing machinery compounded by scarcity of appropriate raw material during the period July 91 to August 92, which made achievement of objectives more time consuming than envisaged; shortage of appropriate packing material; poor infrastructure.

115. It should be noted that a number of options for adequate supply of grain, both in quantity and quality, were explored, including contract farming.

116. During the course of the project, work was undertaken in collaboration with the Kenya Agricultural Research Institute concerning the evaluation and selection of a number of appropriate cultivars with respect to processing, cooking and food quality characteristics. The importance of such studies was emphasised.

117. Slow sales were reported in the early period of the project. A scarcity of alternative foods was reflected in the dramatic increase in sales during the period March - May 1994, coupled with the favourable price of the new products in comparison to food grains available in the market place.

Area chosen for distribution: test marketing

118. Due to the small quantities of *supa mtama* and flour from white sorghum (specific variety unknown), limited market testing was undertaken. Progress achieved in the production of wholemeal flour from brown sorghum grain (Serena, Seredo and local varieties) and finger millet (specific variety unknown) resulted in subsequent publicity and sales promotion.

119. The products were distributed throughout six districts in Nyanza and Western province where sales outlets encompassed retail shops and supermarkets. Sales were also made directly

from the plant. Consumer awareness was further enhanced through free distribution to women and church groups, random distribution to individuals at markets and exhibitions at agricultural shows.

120. Promotional efforts were judged to be modestly effective. It was recommended that a more comprehensive approach was required, coupled with a comprehensive understanding of the potential market.

Consumer acceptability and choice

121. Consumer acceptability studies were limited to brown sorghum flour and concluded that the flour was acceptable, in terms of a number of criteria, namely: colour, taste and aroma of foods prepared from the flour (*ugali* and *uji*). Consumers reported that the price, retailed at Ksh 14.50 per kg, was high.

Financial viability of the plant

122. A preliminary financial assessment of the pilot plant at Kisumu led to the conclusion that such a plant can be operated successfully on a commercial scale in the sorghum producing areas of Western and Eastern Kenya (see table 10). The conclusion was made despite a small loss ascribed to initial difficulties in raw material availability, capacity utilisation and management factors.

123. Given cost-effective processing methods, the 1994 report concludes that adequate consumer demand for dehulled sorghum flour exists.

Table 10 : Financial viability of the Kisumu plant: January 1993 to May 1994 (Source: KIRDI (1994) Final Project Report, unpublished)

	Expenditure (Ksh)	Revenue (Ksh)
Sales		1 910 459.60
Grain	685 722.50	
Grain in Storage		147 007.50
Packaging Material	244 327.60	
Packaging material in storage		55 859.00
Labour	282 795.00	
Vehicle running expenses	280 021.60	
Building Repairs	76 050.00	
Equipment Repairs	29 806.40	
Fumigation	5 000.00	
Sales promotion	74 626.90	
Insurance	63 392.60	
Stationery	52 374.45	
Electricity	30 165.00	
Postage & Box rental	6 602.40	
Assets depreciation	401 165.45	
Total	2 232 049.30	2 113 326.10
Profit/loss	(118 723.20)	

124. In the view of the team, the profitability of such enterprises on the scale of the Kisumu plant is open to further investigation of possible adverse factors before full commercialisation is attempted.

Future developments

125. There is the need for developing micro-level processing methods which are cost-effective and for priority to be given to practical research on technology transfer to micro or small-scale rural entrepreneurial groups.

126. The development of secondary processing for a variety of snack food products such as those being developed in India is well worth investigating, considering the variety of snack and similar food products currently being imported into Kenya.

127. The suggestion was made by Dr Kanne (Director, KIRDI) for a one year secondment of a British expert to help develop large scale EU aid applications for assistance with further processing and technology transfer.

TECHNOLOGY TRANSFER

General Concepts - From NARS to entrepreneurs

128. Technology transfer is one of the most difficult processes to initiate in the development of rural small-scale industries. It should be made clear that the transfer includes not only the hardware but the software which is the associated knowledge and skills necessary for operation. Transfer can refer to a concept, or an idea, or a set of practices, for example quality standards, quality control or nutritional considerations.

129. In the context of this report, technology transfer refers to the communication of knowledge and skills concerning the processing of selected coarse grains from research and university institutes to rural entrepreneurs. These entrepreneurs can be usefully considered at the household or microscale level and the small-scale rural industry level.

130. The possibility of identifying components of the commodity systems with potential for geographical transfer to other regions/countries was also of considerable interest to the mission team.

131. The success of the technology transfer process depends upon a number of factors:

(i) The development of cost effective processing machinery;

(ii) Training in the understanding and operation of chosen machinery or alternatively the availability of such technical advice to optimise production;

(iii) A knowledge and understanding of appropriate varieties for a specific end use; appropriate in terms of functional characteristics;

(iv) The selection of innovators and early adopters for primary and secondary processing for small-scale rural industry. These can be used as growth points for the diffusion of the innovatory practices among other adopter categories, and;

(v) Diagnostic flows of information between the early industrial users and institutes to continually improve and adapt processing methods.

132. In the following sections, findings from India and Kenya are assessed against the above conceptual framework.

Lessons from South Asia

a) Food products

133. As has been noted throughout this report, there appear to be few systematic programmes for the transfer of processing technology in India. There are exceptions, as noted in other sections of the report, but these tend to be localised and of limited duration and not progressing in diffusion beyond the earliest adopters. Exceptions include the notable localised success of APAU working closely with NGOs. Their programme involved most of the elements mentioned above (i - iv) in the development of machinery, training in its use and knowledge of a diversity of food preparations. This programme, however,

lost funding before the diffusion process could progress further.

134. The full diffusion process must involve the use of early adopters as foci for the spread to other adopter categories. This will necessarily involve the development of a broader range and upscaling of the equipment and training in the skills required.

135. Based upon intensive discussion at APAU it is clear from the evidence that there is a persistent demand for such equipment and know-how which has been hindered by lack of resources. Resources seem to be cut off before the innovation became a self-sustaining process.

136. In particular, the experience of APAU highlighted the importance of institutes developing partnerships with early adopters for developing utilisation. It was also highlighted from discussions, visits and relevant documentation that the APAU approach was most effective at the household or microscale level, involving particularly womens' groups.

137. From obervations made, it would seem that diffusion of innovative secondary processes tended to stop at the prototype stage or with the first adopter. This was due to a complex of factors, involving lack of cost-effectiveness of the machine, but the primary cause being a lack of an appropriate institutionalised framework as under (i - v) above.

138. The OFAR approach developed by ICRISAT provided diagnostic feedback between breeders and farmers to develop optimal varieties for on-farm production. This diagnostic process does not seem to exist in primary or secondary processing. Ideas are often conceived within the institutes, screened and evaluated internally, prototypes developed which are then

promoted to industrial users. There was little evidence, with some exceptions, of outside inputs into the innovation process, with feedback and adaptation to meet rural industrial conditions and needs.

139. Systematic training programmes were lacking not only because of a lack, not only of resources, but of an overall policy framework for technology transfer. The dedicated and energetic efforts of individuals could be more effective given such a framework.

b) Industrial products

140. The situation regarding industrial uses of sorghum and millet is at a different stage and operates in a different context. Due to the dedicated and innovative efforts of a few leading academics, a cost-effective technology for starch and sugar production has reached the commercialisation stage. Some early adopters have already started production.

141. The key obstacles, as stressed by our informants, are really the lack of an institutional framework to cover points iii - v above. To put it plainly, take-up is limited to the early adopters and there is no mechanism for further spread to larger areas of industry. Thus, the diffusion process may remain limited in scope and pace. The *ad hoc* efforts to introduce innovations to industry cannot substitute for a systematic programme. These views were supported unanimously by all informants, including those directly involved in technology transfer.

142. It was mentioned that the lack of an effective data base for communication of information and ideas was a serious constraint.

143. One common element stressed was the need for training for small-scale business management, which was comprehensively lacking even within the leading state of Maharashtra.

144. The state of Maharashtra is the foremost industrial state of India and has special financial and training programmes supported by Government finance. These very successful incentives programmes have limited impact upon primary and secondary processing of sorghum and millet due to the specialised nature of the know-how, training and business management problems. It appears that the training they offer is for established markets and products and not for potentially risky areas suitable for entrepreneurs.

145. In Maharashtra's case, a system for selecting early adopters and innovators and associated training is not present for the special needs of sorghum and millet, but the institutional framework exists for the further diffusion among middle adopters who are only prepared to enter viable or established markets.

MAJOR CONCLUSIONS: CURRENT AND FUTURE POTENTIAL

146. Considerable potential exists for the utilisation of sorghum and millet for food products, industrial applications and the use of by-products, including fodder, the basis of which is being realised.

a) In the Indian context

147. In the Indian context potential derives from:

(i) Identification of market segments, consumer preferences and distribution channels for value-added food products with

specific benefits, e.g. generalised health foods, supplementary foods, and products with specific therapeutic effects;

(ii) Extensive research capability and knowledge of varietal characteristics linked with on-farm adaptive research mainly located at ICRISAT and the National Research Centre for Sorghum (NRCS);

(iii) Primary and secondary processing and research capability at CFTRI particularly with regard to a wide range of machinery prototype development and experience of new product development;

(iv) Consumer acceptability for high quality sorghum and millet-based products amongst substantial socio-economic groupings in particular geographic areas. Capability for associated nutrition and food preparation knowledge and skills has been demonstrated by APAU;

(v) Capability for industrial uses is considerable, particularly with regard to starch, alcohol and sugar production. Research capability and industrial applications have been demonstrated by the Agro Product Development Centre and Akola University, and;

(vi) Availability of a marketable surplus for food and industrial uses. Supply is not an immediate constraint, but may become so with increasing utilisation and demand. This will increase the importance of developing efficient marketing systems including distribution, storage and packaging.

b) In the Kenyan context

148. The obvious potential can only be realised by programmes operating at different levels, from individual projects to

broad-based activities, viz:

(i) Collaborative research programme on specific technical and economic constraints,

(ii) Institutionalised arrangements for dissemination of scientific information between leading scientists and institutions within the sorghum and millet growing areas, and

(iii) Technology transfer mechanisms for small-scale rural industrial processing of sorghum and millet for food and industrial uses. This includes technology transfer to and from semi-arid areas in Africa. Systematic programmes for technology transfer between institutions and rural small-scale industry and, additionally, at the household level.

c) Opportunities for geographical transfer

149. There are three main areas where the Indian experience could have useful lessons for African, semi-arid production systems. These are a) the marketing systems, b) micro-level technology suitable for transmission through women's groups and c) snack food development concepts and products currently being developed in India.

a) The regional marketing system in India works efficiently and many of the features described in this report should be considered for transfer to Kenya. In particular, the greater involvement and encouragement of the private sector to engage in small grains marketing, storage and processing as grain market liberalisation proceeds.

b) The micro-level technology which had some initial success in Mysore had the interesting characteristics of a diffusion process of very small-scale, simple machinery through women's groups; the diffusion process being assisted through training of the women's groups by specially-selected instructors through the university.

GENERAL OBSERVATIONS

150. The following points provide some explanatory background to the conclusions reached:

(i) There are certainly areas where prototype development is hindered due to lack of resources, particularly with regard to the development of pearling and milling technology producing product quality demanded by consumers;

(ii) The study revealed that current research tended to be fragmented and isolated, lacking the essential institutional linkages necessary for R&D success. One critical point, for example, is the assessment of cultivars with appropriate characteristics for specific food and industrial uses in addition to the productivity objectives of ICRISAT's OFAR programme. A second point is a lack of marketing and distribution studies to facilitate technology transfer, and;

(iii) Significant institutional failure (with some honourable exceptions) to disseminate current scientific and technological skills and knowledge to the rural community and industry for household and small-scale industrial utilisation, especially in view of the keenness and entrepreneurial spirit evidently present.

151. The study highlighted the critical importance of food quality parameters for successful new product development, both

in terms of processing technology and selection of appropriate cultivars. This is somewhat lacking at the moment.

RECOMMENDATIONS

152. Specific recommendations on the establishment of systems for implementing the programmes suggested above are indicated below:

(i) Surveys for consumer preferences and food acceptability for sorghum and millet-based novel foods. These should be based at APAU in cooperation with other institutes and facilitated through split PhD programmes, academic exchange and a commitment of specialised staff as advisors to the programme;

(ii) Marketing and distribution studies to facilitate market development. Such studies should be centred at ICRISAT as a complementary programme to their production economics studies, closely liaising with other institutes. Such studies would concentrate on market structure, price formation, distribution channels, marketable surplus and primary/secondary processing data in the main sorghum and millet growing areas. It is recommended that long term secondment of an expert in agricultural marketing be proposed supplemented by short term inputs from other relevant experts;

(iii) Prototype development for high quality, cost-effective pearling and milling machinery. Development for this should be centred at CFTRI, provided that an appropriate diagnostic system for technology adaptation is established. It is recommended that the secondment of a processing engineer and short-term inputs from food science, marketing and technology-transfer disciplines are required. In addition, we recommend up to three split PhD's in these areas to provide continuity in the research and development programme;

(iv) Closer analysis of the apparent failure of the previous, institutionalised, technology-transfer systems, and the development and implementation of systems for effective technology transfer;

(v) Study of the effectiveness of NGOs for technology transfer for small-scale, household-based rural industry. A study of this should be centred at APAU with cooperative links with other key areas and institutes;

(vii) Establishment of training programmes in small-scale business management for entrepreneurs in the rural sector for primary and secondary processing of sorghum and the millets;

(viii) Development of a programme for training and academic exchanges between leading institutions within India, Africa and Britain. More specifically, the establishment of split PhD's and post-doctoral fellowships in the areas of processing, logistics, marketing and small-scale business development and technology transfer;

(ix) Establishment of a complementary programme to existing genetic enhancement which emphasises selection and development for optimal primary and secondary processing characteristics. It is recommended that a high level team be established at ICRISAT working in close collaboration with NRCS and other relevant institutes;

(x) A periodic review of processing technologies in India and Africa with special emphasis on their transferability. This would involve a periodic short term commitment by an interdisciplinary team.

153. Collaboration with KIRDI should be actively pursued with a view to obtaining long-term funding for the development of cost-effective primary and secondary processing within the specific country requirements. The aim of such collaboration would be to build on existing work in solving current process engineering problems and also to develop proposals for EU funding with particular respect to technology transfer.

APPENDIX 1
Itinerary

18 November	Fly London - Bombay
19 November	Fly Bombay - Bangalore
20 November	Development of technical and economic appraisal protocol for focus group discussions. Train Bangalore - Mysore
21 November	Mysore: Central Food Technological Research Institute (CFTRI), Grain Science and Technology Department: Dr S R Ali (Head) Dr N G Malleshi (Senior Scientist) Dr H V Narasimha (Senior Scientist) Dr C M Sowbhagya (Senior Scientist) Introductory discussion: overview of aims and key areas of interest. Development of provisional work programme.
22 November	Mysore, CFTRI Mr A S Jhangiani (Owner, small-scale rural industry, Maharashtra State) Dr Mahadeviah (Head, Packaging) Dr Pillai (Head, Technology Transfer and Marketing) Dr P H Rao (Head, Milling and Baking Technology) Dr L Srinivas (Head, Nutrition) Dr D Rajalakshmi (Head, Sensory Analysis and Consumer Acceptability) Small-scale processing operation, Mysore
23 November	Mysore, CFTRI Mr B Beharrell Mr Pillai (Technology Transfer and Marketing) Dr Mahadeviah (Packaging) Dr Narasimha (Grain Science and Technology)

	Ms K Wellings
	Dr S R Ali; Dr N G Malleshi and Dr C M Sowbhagya (Grain Science and Technology) Dr S V Rao (Nutritionist, retired)
24 November	Mysore, CFTRI
	Dr V Prakesh (MD, CFTRI) Dr S R Ali and Dr H V Narasimha (Grain Science and Technology)
	Consolidation and administration for remaining work programme.
	Train Mysore - Bangalore, Mr B Beharrell
25 November	Mysore, Ms K Wellings, CFTRI
	Dr P H Rao (Milling and Baking Technology) Dr S R Ali; Dr H V Narasimha and Dr N G Malleshi (Grain Science and Technology)
	Train Mysore - Bangalore, Ms K Wellings
	Bangalore, Mr B Beharrell
	Government Marketing Board: Name ? (Senior Statistician)
	Bangalore Agricultural University: Prof ? (Head, Agricultural Economics)
26 November	Fly Bangalore - Hyderabad
	Consolidation, itinerary for Hyderabad
	Ms K Wellings
	Dr P C Stevenson (Chemical Ecology, NRI)
27 November	Hyderabad: College of Home Science, Andhra Pradesh Agricultural University: Dr C Rao (Formerly, Dean (?)) Dr R Vatsala (Principal) Dr M U Reddy (Associate Professor, Department of Foods & Nutrition) Dr K Kaur (Assistant Professor, Department of Foods & Nutrition)
	Review of literature.

28 November	Hyderabad
	International Centre for Research in the Semi-Arid Tropics (ICRISAT):
	Mr B Beharrell
	Dr M Whitaker (Resource Management Programme) Dr T G Kelly (Agricultural Economics) Dr P Rao (Agricultural Economics) Dr R Singh (Agricultural Economics)
	Ms K Wellings
	Dr V Subramanian (Senior Biochemist) Dr U Singh (Senior Scientist, Crop Quality Unit) Dr J Lenne (Pathology, NRI) Dr P C Stevenson (Chemical Ecology, NRI) Ms H J Turner (Food Scientist)
30 November	Hyderabad, Ms K Wellings
	National Research Centre for Sorghum, All India Coordinated Sorghum Improvement Project: Dr B S Rana (Project Coordinator) Dr B Ravi (Senior Scientist)
	Faculty of Home Science, Andhra Pradesh Agricultural University: Dr V Khader (Professor and Head) Dr V Vimla (Associate Professor) Dr P Yasode (?) (Assistant Professor)
	Hyderabad, Mr B Beharrell
	ICRISAT: Dr K Chung (Economics & Nutrition) Name ? (Information Officer)
	Review of literature and reports
1 December	Public Holiday
2 December	Hyderabad
	College of Home Science, Andhra Pradesh Agricultural University: Dr R Vatsala (Principal) Dr M U Reddy (Associate Professor, Department of Foods & Nutrition)

	Field visit to NGO, Miyapur
3 December	Fly Hyderabad - Bombay
5 December	Bombay
	Mr A S Jhangiani & Mr M Jhangiani (Small scale rural industry)
6 December	Bombay
	Directorate of industries, Government of Maharashtra: Mr Dongre (Joint Director of Industries) Mr Maalwade (Officer)
7 December	Bombay, Ms K Wellings
	Professor R B Somani (Head, Agro Products Development Research Centre, Akola)
8 December	Nasik
	Small-scale rural industry, Nasik
9 December	Consolidation; report structure
10 December	Fly Bombay - Addis - Nairobi
11 December	Draft BTOR
12 December	Public Holiday
13 December	Nairobi
	Kenya Industrial Research and Development Institute: Dr -Ing H L Kaane (Director) Deputy Director ? Mr S A Moturi (Head, Cereals & Legumes Section) Mrs M A Krhoda (Nutritionist) Mr A O Makokha (Food Technologist) Mr S M Wambugu (Food Technologist)
14 December	Fly Nairobi - London

APPENDIX 2

Production and Marketing Data - KANATAKA

SEASONALITY AND PRICE QUANTITY RELATIONSHIPS FOR A SELECTED REGIONAL MARKET 1981-2 1993-4
COMMODITY JOWAR (White)
APMC GULBARGA
(ARRIVALS IN QTLS)

	1981-82		1982-83		1983-84		1984-856	
MONTH	ARRIVALS	Modal price R's	ARRIVALS	Modal Price R's	ARRIVALS	Modal Price R's	ARRIVALS	Modal Price R's
JUL	5846	190	2194	185	4695	215	2775	180
AUG	3507	190	1872	175	1140	215	2392	180
SEPT	2329	210	2218	180	4068	230	3589	185
OCT	3026	210	1553	170	3606	225	3156	200
NOV	2394	215	2010	180	3755	220	4097	215
DEC	1640	235	2151	175	3325	225	3035	235
JAN	1316	240	2348	180	4288	225	2226	235
FEB	1804	180	2383	170	3669	160	2234	210
MAR	1513	180	1552	170	4526	215	3582	190
APR	2739	180	5387	180	5151	190	4212	225
MAY	2430	175	3067	175	2464	190	4313	218
JUN	1875	180	2350	170	4053	190	3667	215

COMMODITY JOWAR (White)
APMC GULBARGA
(ARRIVALS IN QTLS)

1985-86			1986-87		1987-88		1988-89	
MONTH	ARRIVALS	Modal price R's	ARRIVALS	Modal Price R's	ARRIVALS	Modal Price R's	ARRIVALS	Modal Price R's
JUL	4750	190	2946	190	5594	200	793	250
AUG	3434	180	3996	190	7071	200	673	250
SEPT	3390	185	3599	190	6272	200	479	250
OCT	3773	185	4362	180	4066	200	576	300
NOV	3361	200	4528	190	4123	224	719	340
DEC	3773	230	3962	180	3659	245	729	400
JAN	3142	225	3277	195	2826	250	903	390
FEB	2599	225	4011	190	2491	250	893	350
MAR	4883	220	3235	185	2740	250	2561	300
APR	7047	200	8420	205	4487	250	3030	360
MAY	6293	145	6711	190	2101	240	1747	360
JUN	3913	190	6845	185	1761	250	1655	360

	1989-90		1990-91		1991-92		1992-93	
MONTH	ARRIVALS	Modal price R's	ARRIVALS	Modal Price R's	ARRIVALS	Modal Price R's	ARRIVALS	Modal Price R's
JUL	262	400	161	220	2975	350	3658	550
AUG	1552	390	160	200	3918	350	3966	565
SEPT	1646	350	160	200			2236	550
OCT	1276	350					2888	530
NOV	1121	330	185	230	1830	580	2545	550
DEC	1103	340	186	260	1145	600	3039	550
JAN	371	200	225	290	839	600	2000	425
FEB	619	250	200	260			5856	400
MAR	6498	250	215	300			9625	385
APR	3400	250	275	350	3321	595	5263	350
MAY	3121	250	232	340	2138	550	4347	350
JUN	2861	230	264	350	2062	650	4877	350

COMMODITY JOWAR (White)
APMC GULBARGA
(ARRIVALS IN QTLS)
1993-94

MONTH	ARRIVALS	Modal price R's
JUL	430	300
AUG	3467	300
SEPT		
OCT	5655	296
NOV	11407	325
DEC	5611	370
JAN	8156	350
FEB	8140	350
MAR	6562	350
APR	11002	400
MAY	7638	360
JUN	NA	NA

APPENDIX 3

New Product development:
Central Food Technology Research Institute, Mysore

1. Secondary processing is closely linked with new product development and a wide range of machinery prototype development, much of which is being done at CFTRI. The following details successful exploratory trials concerning flaking, noodle development, popping and supplementary foods.

Jowar flakes

2. The operational capacity stands at a batch size of 500kg per hour:

(a) Cleaned *jowar* grains are mixed with 3-4% water (surface coating only).

(b) The grains are subject to parboiling and subsequently transferred to a dry roasting unit (about ten feet long by six feet high and six feet wide) which is about four feet above the ground.

(c) The roasted grains are then pearled by an abrasive process and transferred to a flaking unit.

(d) Flakes are produced by passing the roasted grains through horizontally revolving smooth rolls (single pass).

3. Recent modifications to the flaking unit have included: micro adjustment of the roll gap size (now belt rather than gear driven); an improved scraping action; modification of the rolls to reduce misalignment.

Jowar noodles

4. The prototype machine was developed at CFTRI workshops. Exploratory studies have been successfully undertaken with maize and work is continuing on sorghum and millet products.

(a) A quantity of flour and water are mixed and cooked for one minute using a moderate heat, stirring continuously.

(b) The mixture is kneaded to form a dough.

(c) The dough is extruded through a die (1.3mm diameter, adjustable) to produce noodles.

(d) The noodles are pressure steamed and dried (60-80ºC).

Partially popped and ground finger millet flour: Small-scale processing enterprise, Mysore

5. The process developed at CFTRI is highlighted below:

(a) Cleaned finger millet grains are mixed with 5% water to achieve a moisture content of approximately 16%.

(b) The grains are passed through a rotating drum which is heated by kerosene oil. The drum contains fine sand particles which raise the internal temperature to 260 C, facilitating popping. Sand is refed through the rotating system.

(c) The partially popped grain is ground and packaged in 500g lots into food grade film sealed by a candle flame.

6. One example of technology transfer and know how investigated by the team was a small processing enterprise in

Mysore which produces *Hurittu*, a partially popped and ground finger millet flour which is sold within a strictly limited area, mostly with a 10km radius.

7. The marketing constraint was simply the limit of the logistics reach of one man on a small motorbike plus the small quantities left at each outlet. In addition cash flow back to the entrepreneur via the distributor only happened upon the sale of the product, a strict limitation on the growth of the enterprise. Further the entrepreneur was set upon the idea of a family business and working with a trusted distributor who would not "swallow up all the profit". He was hampered by the intermittent nature of the batch production process.

8. Technical constraints affecting food quality was significant contamination with sand during partial popping of the grain as sand is used as the heating agent. CFTRI are investigating alternative heat transfer medium. A working model using air to transfer heat to the grain is being developed but plans for upscaling and commercialisation are hindered by lack of resources and industrial partnerships.

9. Technical development work currently being carried out in this respect concerns the identification of suitable sorghum and millet varieties. Types of grain required for popping specifically exclude those with a thick pericarp. For example, pearl millet variety CO6 proved effective and was successfully used in trials developing popped supplementary foods.

Supplementary foods:

10. The following two flow charts are taken from a component of a PhD programme undertaken at CFTRI which explored the popping of pearl millet and the development of a supplementary food based on popped millet (Source: Hadimani N A (1994)

Studies on Pearl Millet (*Pennisetum americanum*) grain quality with special emphasis on milling and popping of millet. PhD Thesis, submitted).

Chart 1: Preparation of Popped Supplementary Food

Note: The amino acid profile satisfies the FAO/WHO/UNU specifications (1985) for supplementary foods.

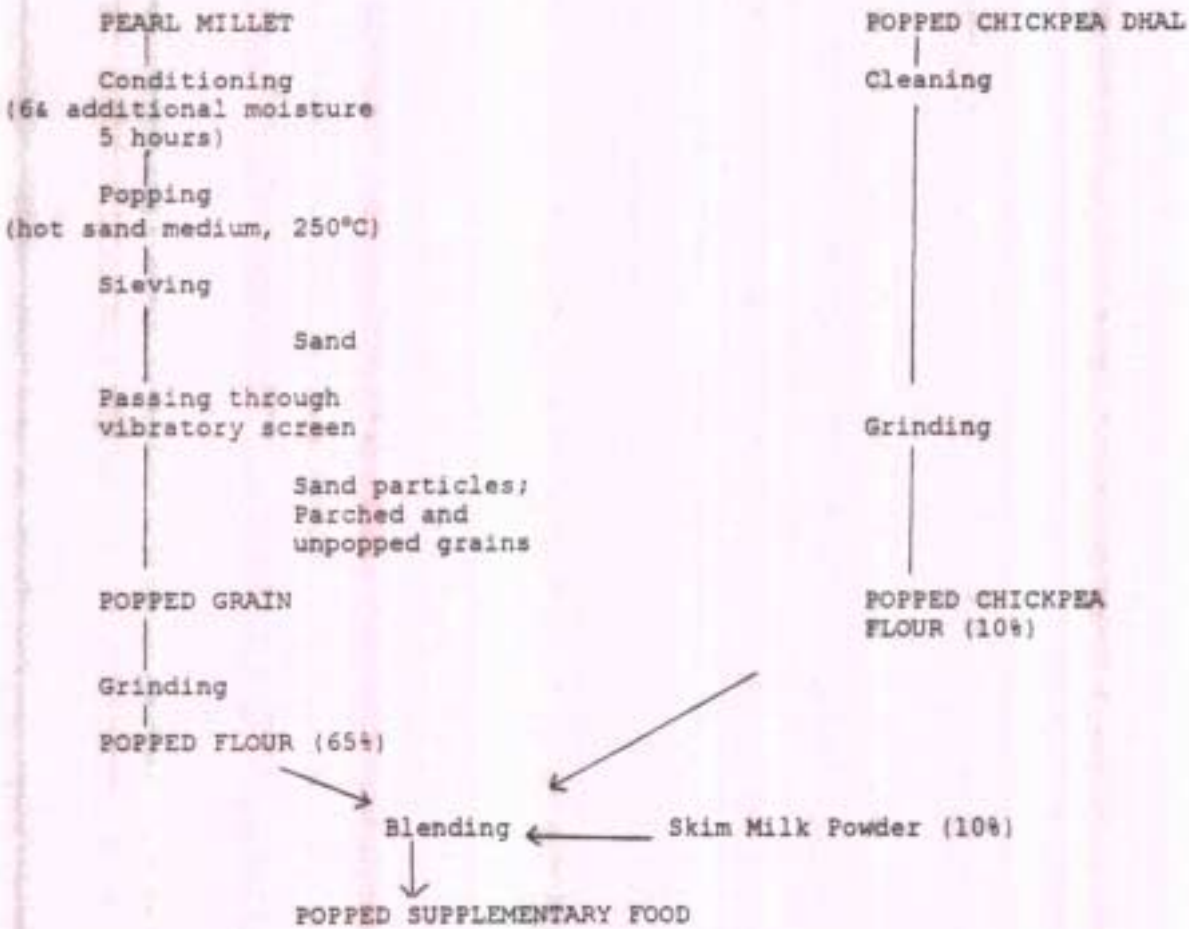
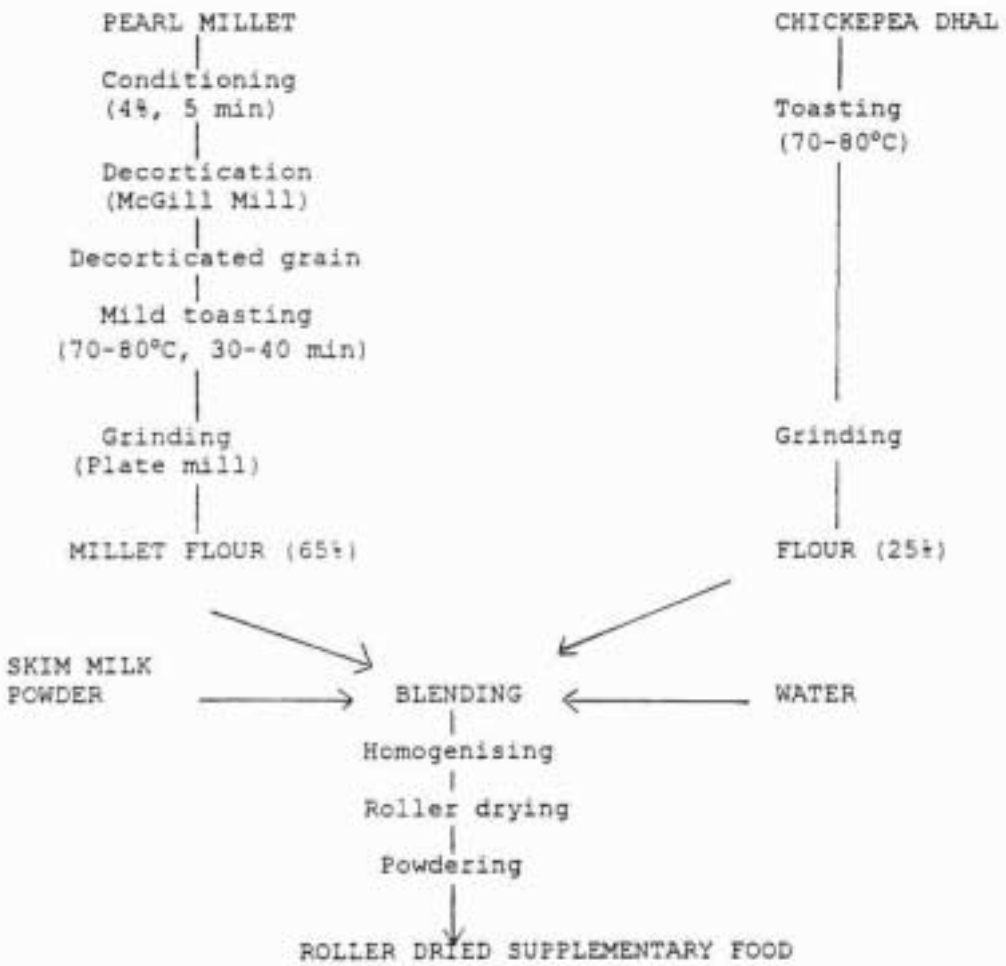


Chart 2: Preparation of Roller Dried Supplementary Food



APPENDIX 4

Project profile for sorghum dehulling unit

Production Target	30 quintals of sorghum products		
Time of production	8 hours		
Number of personnel	3		
Anticipated working days	25		
Land and building			
Rent for preparation room, raw material room and Machinery room	8' x 10' x 10' 8' x 10' x 10'	Rs.	Ps. 500-00
Machinery and equipment			
Dehuller			13,000-00
Flour Mill			6,500-00
Weighing machine with weight box			1,200-00
Sealing machine			100-00
Accessories like tubs, sieves, winnowers plastic sheets etc			400-00
Storage drums			500-00
			Rs. 21,700-00
Salaries and wages (per month un-skilled labour - 3 at the rate of Rs. 15/-day)			1,125.00
Utilities per month. Power requirement for running			1,100.00
The dehuller and mill packaging and marketing charges			1,100.00
			Rs. 2,200.00

Amount required for preparation of 30 quintals of sorghum products/day

Raw Material	Amount (quintal)	Rate/quintal	Cost Rs.	Ps.
Sorghur	36	300-00	10,800-00	

Working capital per month	183-83
Machinery depreciation cost ie (10 years life or 3000 working days)	
Rent	500-00
Utilities	2,200-00
Salaries and Wages	1,125-00
Amount required for raw material purchase	10,800-00
	14,805-83 or 14,810-00
Profit/month (Income-Working capital - Profit)	
Income from sales of 10 quintals of dehulled sorghum (at the rate of Rs.6/kg	6,000-00
Income from sales of 10 quintals of dehulled sorghum flour (at the rate of Rs. 6.50/Kg)	6,500-00
Income from sales of 10 quintals of dehulled sorghum save (at the rate of Rs. 6.50/Kg)	6,500-00
Total income	Rs. 19,000-00(a)
Working Capital	Rs. 14,810-00(b)
Profit (a - b)	Rs. 4,190-00*

* All Calculations made on the basis of rates prevailing in 1989-90 Andhra Pradesh, India

(Source: Geervani P and Vimala V (1993) Rural Food Enterprises, Operational Research on Development of Sorghum Food Enterprises for alternate uses and supplementary feeding. Andhra Pradesh Agricultural University).

APPENDIX 5

New Developments in Industrial Usage of Sorghum and Millet

Case 1: Liquid glucose production from sorghum grains

a) Financial feasibility analysis

	Rate/MT (Rs.)	Total Rs. in lakh
1. **Receipts**	9500.00	142.50
(i) Liquid glucose @ 5 TPD; 300 working days/year, 1500 MT/year	3000.00	16.50
(ii) Sale of by product 550 MT		159.00
(iii) Total receipts		
2. **Expenditure**		
(i) Raw material 2500 MT	3000.00	75.00
(ii) Enzymes and chemicals		28.00
(iii) Utilities steam, Elect., water		10.00
(iv) Insurance		6.0
(v) Salary and management expenses		8.0
(vi) Pre operative and other expenses		4.0
(vii) Depreciation		10.00
(viii) Interest		10.00
(ix) Total expenditure		151.00
3. **Profit (1-2) (Minimum)**		8.00
4. Cash Accrusal Depreciation 10.00		
Profit 8.00		18.00
Rough estimate of Project cost		
Land and land development	3.00	
Building 11.00		
Machinery and Equipment	60.00	
Misc. 3.00		
Working capital (1 month)	12.00	
	90.00	

(Source: Somani R B et al (1994) Liquid Glucose from Sorghum Grains. In: Proceedings of the VII Joint Convention of the Deccan Sugar Technologists Association (India) and The Sugar Technologists Association of India, New Delhi: Seminar on "To Explore the Possibilities of Cultivation and Processing of Supplementary Sugar Crops - Sweet Sorghum, Sugar Beet, Maize etc).

b) **Overall demand factors for liquid glucose up to 1996**

Sr. No	User Sector	Present demand (1991)	Future demand (1996) Tonnes
1.	Confectionery	78122	125816
2.	Pharmaceuticals	14648	23591
3.	Food Productions and Miscellaneous uses	4883	7864
	Total	97653	157271

Estimated Sectorwise Demand for Dextrose Monohydrate

Sr. No	User Sector	Present demand (Tonnes)	Future demand of DMH 1996 (Tonnes)
1.	Repackers Market	29556	47600
2.	Pharmaceuticals	5911	9511
3.	Dextrose Anhydrous	3941	6347
	Total	39408	63458

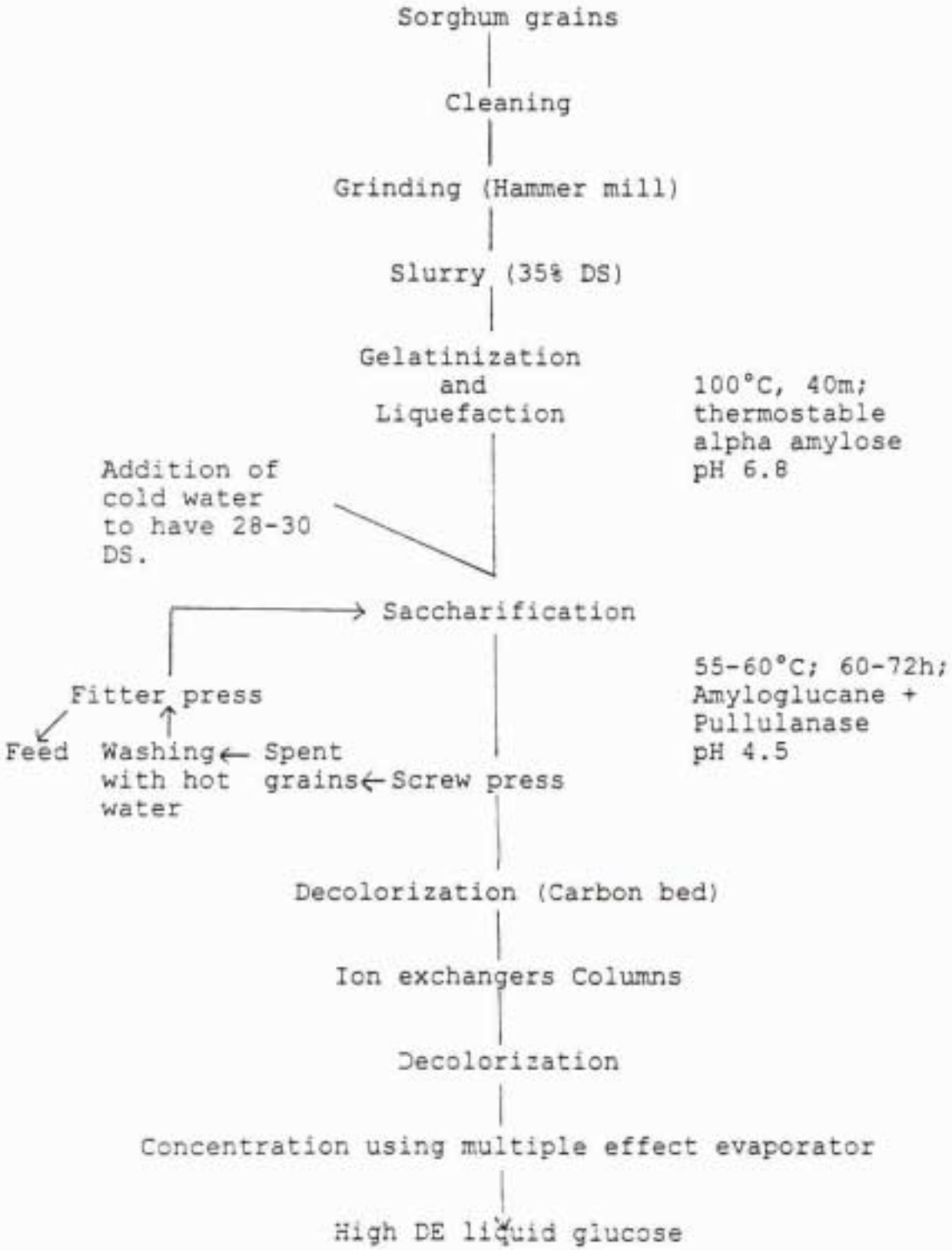
Estimated Demand for Sorbitol (Sectorwise) up to 1996

Sr. No	User Sector	Present demand (Tonnes)	Future demand 1996 (Tonnes)
1.	Pharmaceuticals	2788	44909
2.	Toothpaste	16731	26945
3.	Miscellaneous uses	6084	7765
	Total	50700	79619

Estimated future demand for HFS

Year	Production Mn. cases	Sugar Consumption (Tonnes)	Demand for HFS (Tonnes)
1991	130	51840	-
1992	144	57024	-
1993	160	63360	6336
1994	178	70488	10573
1995	197	78012	11702
1996	219	86724	13009

c) Flow diagram of liquid-glucose production



Case 2: The production of starch

a) Flow chart showing processing steps in the production of starch (Source: Somani, R.B. (1994) Unpublished research note)

b) Typical financial analysis of a starch production enterprise

(Figs. in Lacs)

LAND:		
2 Hectares for Factory and 5 Hectares for Cultivation, side development.		5.00
BUILDING:		
Factory shed, R.M., F.P. and stores godown, office, labour quarter, watchman cabin, compound wall.		40.00
PLANT AND MACHINERY:		80.00
Vehicles		5.00
Furniture		3.00
MSEB Deposit (Cost of Transformer)		2.00
Pre-Operative Expenses		
Interest during construction irrection period, consultancy charges, other expenses regarding formation, etc.		13.00
Margin for Working Capital		36.00
		184.00
MEANS OF FINANCE		
CAPITAL:		
Own	8.00	
Government Share	76.00	
		84.00
BANK TERM LOAN:		100.00
		184.00
PRODUCTION COST		
Raw Material		
30 M.T. per day for 300 W.D. = 9000 M.T. @ 2750/-		247.50
Chemical		
30kg per day for 300 W.D. = 9000kg @ 15/-		1.35
Power		
5000 Unit per day for 300 W.D. = 1500000 unit @ 2/-		30.00
Wages		

50 labour @ 30 per day = 1500 x 300 W.D. 4.50

Steam

300 Rs. per ton of starch so 300 x 15 = 4500 per day x 300 W.D. 13.50

Stores, Packing and other Mfg. Exp.

Rs. 6000 per day x 300 W.D. 18.00

TOTAL Rs. 314.85

ADMINISTRATIVE AND OTHER EXPENSES

Salary Rs. 50000 P.M. x 12 M 6.00

Interest

Term Loan 100 lacs @ 18%	18.00	
W.C. Loan 54 lacs @ 20%	10.80	
		28.80

Other Expenses

Viz., Insurance, Telephone, Postage Printing and Stationery, Legal Fees, and other administrative Expenses Rs. 1.5 lacs p.m. x 12 M 18.00

Depreciation

Building @ 10% of 40 lacs	4.00	
Plant & Machinery @ 25% of 80 lacs	20.00	
Vehicles @ 25% of 5 lacs	1.25	
Furniture @ 10% of 3 lacs	0.30	
		25.55

Pre-operative Expenses

Not Capitalized (1/10 written off) 00.65

79.00

SALES

Starch

Per day production 15 M.T. x 300 W.D. = 4500 M.T. @ Rs. 7500 337.50

Oil

Per day production .60 M.T. x 300 W.D. = 180 M.T. @ Rs. 16000 28.80

Oil Cake

Per production .9 M.T. x 300 W.D. = 270 M.T. @ Rs. 3000 8.10

Crude Fibre

Per day production 7.5 M.T. x 300 W.D. = 2250 M.T. @ Rs. 1000	22.50
Glutelin	
Per day production 1.5 M.T. x 300 W.D. = 450 M.T. @ Rs. 3000	13.50
	410.40

PROFITABILITY

GROSS PROFIT

Sales	410.40	
Less: Cost of Production	314.85	
		95.55

NET PROFIT

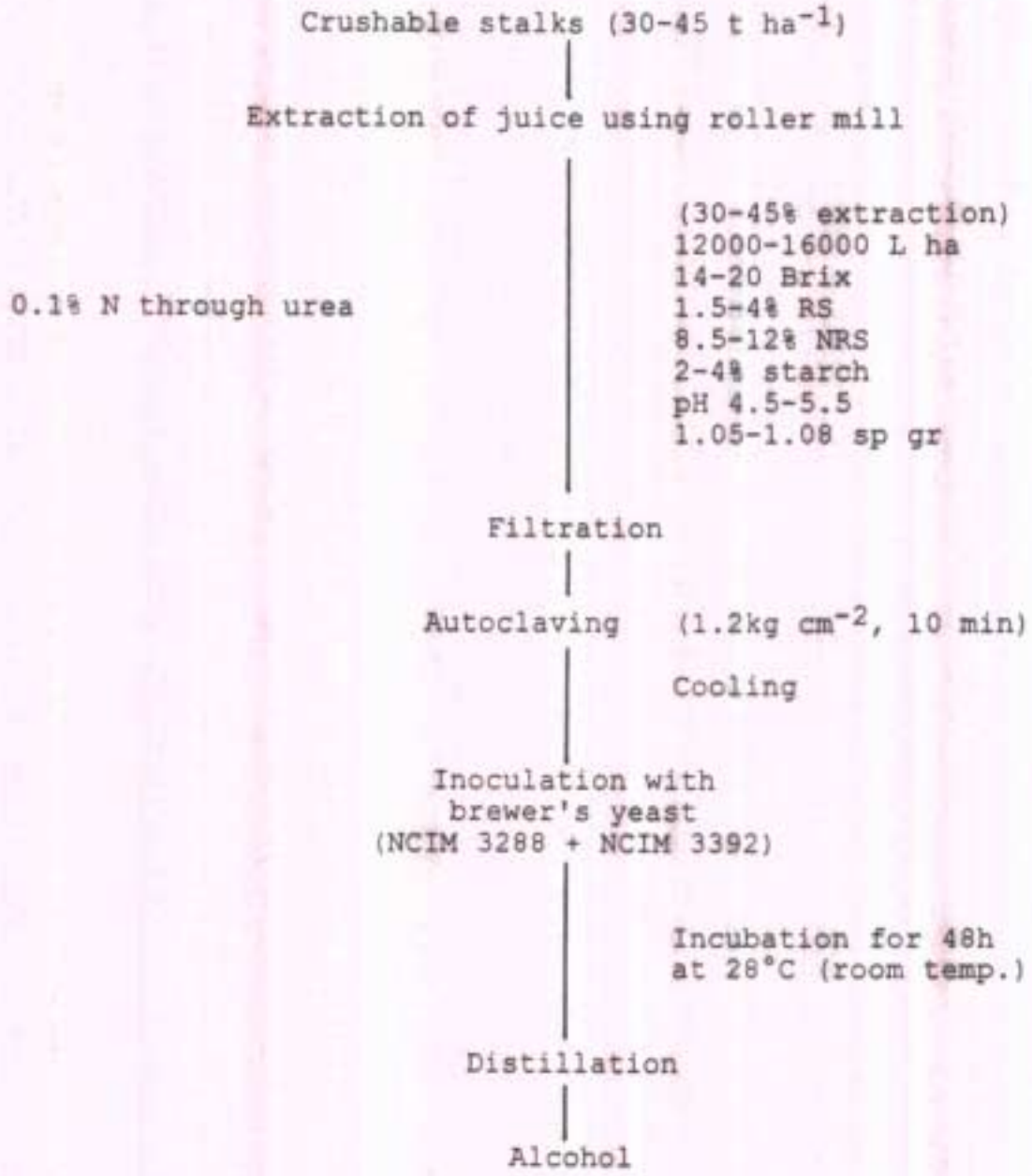
Gross Profit	95.55	
Less: Adm. Expenses	79.00	
		16.55

CASH SURPLUS

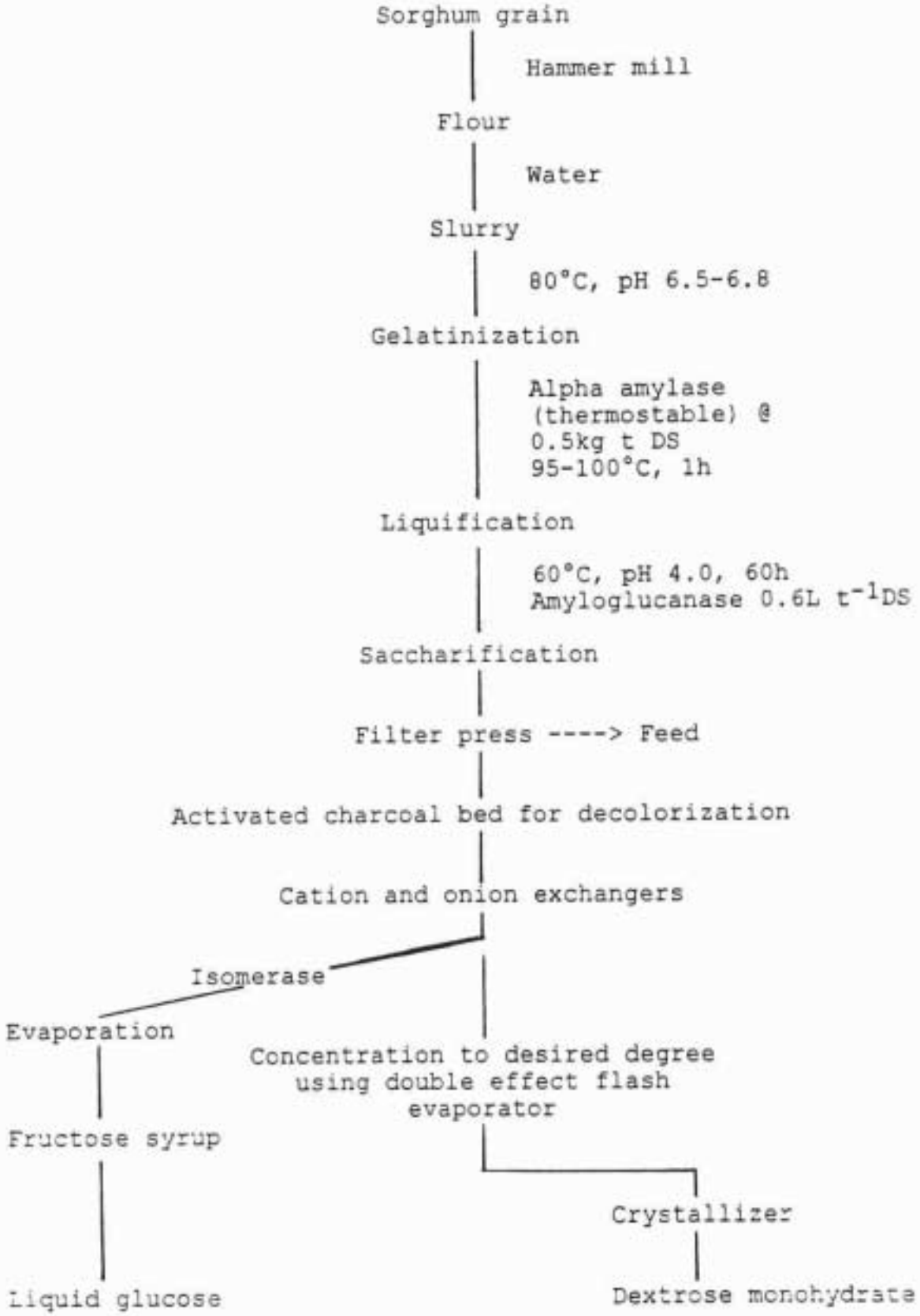
Net Profit (Before Tax)	16.55
Add Depreciation	25.55
Add: Pre-operative Expenses (Written off)	00.65
	42.75
Less: Repayment of Term Loan	20.00
Available for Income Tax and distribution dividend	22.75

(Source: Somani R B (1994) Unpublished research)

Case 3: Alcohol production from sweet sorghum stalks



Case 4: Production of sugars from sorghum grains



Case 5: Alcohol production from Molasses and Sorghum Grain

PARTICULARS	JOWAR GRAINS
Cost of raw material (Rs/MT)	2500-3000
Excise duty (Rs/MT)	---
190 Proof Alcohol yield (1/MT)	340-375
Yield of Neutral spirit (1/MT)	340-375
Process cost of alcohol (Rs/KL)	4000=00 new unit
Process cost of Neutral spirit (Rs/KL)	---
Steam reg. (t/KL)	2
Electricity (kW/kV)	160-200
Spent wash (K1/K1 of alcohol)	10
BOD of spend wash (ppm)	13000-15000
No. of columns reqd. for neutral producton	2-3
By product if any (kg/MT)	250-300 Containing 24-30% protein
Industry Run period (days/yr)	300
Approximate variable cost of production of neutral spirit (Rs/l)	19=00
*Other info	Spend wash light coloured with less BOD and COD; can be used for aquaculture or irrigation.

Case 6: Production of rectified spirit from Blackened Sorghum

Variable Costs of Production

No. of working days	300/year
Starch content in normal grains in cultivars commonly grown	670-700 kg/t^{-1} grain
Starch content in blackened grain	660-682 kg/t^{-1} grain
Fermentable sugar /t^{-1} of blackened grains	660-682 kg/t^{-1} grain
Alcohol yield from blackened grain (NA)	320-340 l/t^{-1} (minimum)
Fermentation efficiency	92-95 %
Distillation efficiency	98.5 %
Plant capacity	10 Kl/day^{-1}

RAW MATERIAL	CONSUMPTION		RATE (rS.)	TOTAL COST/YEAR (rS. IN LACS)
	PER DAY	PER YEAR		
Jowar grains	30 MT	9000 MT	2800/MT	252.00
Enzymes a amylase	30 kg	9 t	13.5t	450000 T
AMG	15 kg		4.5t	
Steam	35	10500 MT	300/T	31.5
Electricity	1600 kW	4.8 Lac/kW	1.5/kW	7.2
Process water	200 m^3	60000 m^3	1.00/m^3	0.06
Cooling water	150 m^3	45000 m^3	1.00/m^3	0.05
Acid	8 kg	2400 kg	3.00/kg	0.07
Antifoam agent	10 kg	300 kg	20/kg	0.06
Yeast	Only during start up			
Total variable cost				344.94
Less credit for spent grains about 25% of grain		2200 MT	3000/MT	(-)66.00
Net variable cost				278.94
Neutral spirit produced		29.5 lac L		Rs. 9.45/L