Technical Manual

On

Processing, Value Addition, Preservation and Packaging of Potential Agro-Horticultutre Crops of Meghalaya for Sustainable Value Chain And Entrepreneurship

Sponsored By

Meghalaya Livelihood and Access to Market Project
Integrated Basin Development and Livelihood Development Program (IDBLP)

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MEGHALAYA

M E S S A G E

It is my firm belief that Meghalaya has the potential to emerge as a regional hub for food processing. It will however, take some time before we can actualize our state's potential because our entrepreneurial base is still not fully established. We will need to first focus on orienting the entrepreneurial skills of the people of the state toward food processing. Now that we are experiencing surpluses in several agricultural and horticultural commodities, the time to orient them is now.

It is in this context that an initiative to organize this two day workshop on the 'Opportunities for the Food Processing Sector in the state of Meghalaya "has been conceptualized by the Agriculture Department in coordination with the MBMA and the MIE. The principal objective of this exercise is to establish a platform and direct the state's potential entrepreneurs to the myriad opportunities that exist in the food processing sector.

I am also happy to learn that a Technology Manual for Food processing is now ready and will be released. The Manual will give the readers the requisite insights about the various processes and technologies required to be grounded for adding value to the surplus commodities of the state. I look forward to seeing the day when our processed food products will reach the global markets.

This Manual will be of value not only to the interested entrepreneurs of the state but also to those who wish to set up food-processing units in the state.

I hope the two day deliberations will kick-start the process of making Meghalaya a food processing hub in the region.

(Conrad K. Sangma)

Preface

Meghalaya known as “the abode of clouds” is one of the states in North East India that has favourable agro-climatic conditions suitable for the growth of diverse agro-horticultural crops ranging from different fruits, vegetables and spices. The state in spite of having vibrant mining and tourism sectors is predominantly an agrarian economy where nearly 10 per cent of the geographical area is under cultivation and agriculture and allied activities provide livelihoods to about 80 per cent of its total population. However, the agriculture in the state is mainly characterized by low productivity and unsustainable farm practices including Jhum cultivation in some parts. Therefore, despite the significant number of population being engaged in agriculture, the contribution of agriculture and allied sectors to the State's GDP is only about one-third and most of the population engaged in agriculture remains poor. The major important agro-horticultural crops in the state are rice, maize, pineapple, banana, strawberry, turmeric, ginger, black pepper, long pepper, bay leaf, cinnamon, tomato, potato, squash and different other vegetables. Though the productivities of these crops are low, the productions as well as the area covered under these crops have significantly increased over the years. Therefore, the state can accelerate its economic growth and development of its population by channelizing these agro-horticultural resources in to the prospective national markets through proper processing and sustainable value chain development. The value chain linkages will not only increase the income by linking their produces with markets but also can open the much required opportunities for employment by development of small and medium scale food processing entrepreneurships in different potential supply and value chain clusters of the state.

A comprehensive attempt is therefore made through this technical manual to explore the possibilities of agro-horticultural value addition for entrepreneurship development in the state of Meghalaya. A detailed account on different kinds of value added products which can be processed from these potential agro-horticultural crops and the preservation and packaging requirements for each of these value added products along with the required machineries for processing and packaging is given in this manual. Further, an attempt is made to analyze the challenges and strategies for sustainable agro-horticultural value chain and entrepreneurship development in the state. It is opined that in spite of having considerable potential for growth of food processing in the state, there are many inherent constraints that may act as impediments for sustainable development of agro-horticultural value chain and food processing entrepreneurship in the state. Therefore, for evolving successful value chain, it is must to have a thorough understanding of these constraints and develop a comprehensive strategy at the planning and organizational stages to avoid these problems at the later stages of value chain and entrepreneurship development in different clusters of agro-horticultural resources. Therefore, a detailed account for some of the significant constraints relevant to NE particularly Meghalaya has been given in the last chapter.

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1. Food Processing, Agro-horticultural Value Chain and Entrepreneurship Development: The Indian Scenario and Prospects in NE and Meghalaya

1.1. Food Processing Sector: The Indian Scenario

India has traditionally been a domestic demand driven economy unlike the advanced industrial economies like USA, European Union, China and others which mainly depends on export as a basic driving force of their economic growth and development. The main driving force of Indian growth is basically coming from its increasing purchasing power of the huge middle class population that is expected to be around US $3.6 trillion by 2020. Structurally, Indian economy has been agrarian in nature where agriculture plays a vital role by way of contributing around 14.5 % to the national GDP and engaging around 70% people for earning their livelihood from agriculture and other allied activities. India with the production of 277 million tones of food grains, 299 million tones of oil seeds (Agri. Stat. at a Glance 2017, GoI), 295 million tones of horticultural produce (Indian Hort. Database 2017, GoI), 165 million tones of milk, 7.4 million tones of meat and 88139 million nos of egg production (Basic Animal Husbandry & Fisheries Statistics 2017, GoI) has come a long way in food production and thus emerged as a self reliant country. However, in spite of this achievement, ensuring future food and nutritional security on a sustainable basis is a huge challenge as Indian agriculture is seized by numerous problems like climate change, soil fertility degradation, increased small and marginal holdings (85% small and marginal farmers), increased population base of 1.27 billion, Census of India 2011 (growing at the rate of 1.58 per cent per annum), inadequate farm infrastructure, lack of farm mechanization, inadequate credit disbursement, inefficient marketing, huge wastage of agricultural produce and many more to name. In this context, food processing can play a vital role not only to minimize wastage, add value and preserve agricultural produces but also to turn agriculture as a profitable activity by integrating it with market driven business model through the development of sustainable high value food value chain and entrepreneurship in the agrarian sector.

1.2. Prospects and Gap in FPI Sector

Today, Food Processing Industry (FPI) is seen as a golden sector. Performance of this sector reveals that FPI GDP has grown at an average annual growth rate (AAGR) of 8.5 per cent than the 7.08 per cent AAGR of overall GDP in the country during the last five years. Other economic indicator such as employment, fixed capital formation, credit flow, FDI and export are also on the higher growth trajectory. This upward trends in all the major performance indicators are further supplemented by the prospect of market expansion on account of increasing trend towards processed food consumption. Indian food and grocery market is the 6th largest in the world with retail contributing 70 per cent of the sales. Rising consumer expenditure is expected

to reach US$ 3.6 trillion by 2020 offering huge opportunities to the sector players. India ranks first in the world in production of fruits and second in vegetables, accounting roughly 10 and 15 per cent of total global production respectively. India have a strong and dynamic food processing sector playing a vital role in diversifying the agricultural sector, improving value addition opportunities and creating surplus food for agro-food products. However, in spite of good performances and huge opportunities in terms of increased agricultural production and large market size, the Indian FPI sector has a long way to go beyond its current average processing of 10 per cent (1 per cent of meat and poultry, 2 per cent of fruits and vegetable, 12 per cent of fishery resources and 37 per cent of milk produced. Thus, clearly the level of food processing is comparatively low in India than other countries like Brazil (30 per cent), USA (70 per cent) and Malaysia (82 per cent). Therefore, the national policy aims to increase the percentage of food being processed in the country to 25 per cent by 2025.

1.3. High Value Agriculture: Structural Changes in Production, Consumption and Trade

Interestingly, during the last three decades, there has been a significant structural change in agriculture in terms of consumption, production, output value and trade. In one hand the share of traditional agricultural commodities in production, area under cultivation, consumption and trade is decreasing and on the other hand, the share of horticulture and other non-traditional high-value agricultural commodities like milk and milk products, fishery output etc are showing an increasing trend in all these parameters and thus representing an important source of potential income growth for agrarian community dominated by 85% small and marginal farmers. There has been a shift in consumption pattern away from cereals to high value agricultural commodities like livestock products, fruits and vegetables and fisheries product both in rural and urban areas across states and income groups during the last three decades. These changes in demand pattern impacted the farming community in such a way that they have also responded to the market signals and gradually shifted their production pattern to meet the growing demand for high-value commodities. This is reflected in the increasing production of high value agricultural commodities with increasing area and resources allotted for cultivation of these commodities. Therefore, the ultimate impact of these changes in consumption and production pattern led to the greater share of output value of high value agricultural commodities in total value of agricultural output and consequent greater share in trade.

1.4.Agro-horticultural Value Chain and Entrepreneurship Development: The Prospects in NE and Meghalaya

1.4.1. North East India: Prospects

North East Hilly Region like mainland India has traditionally been an agrarian economy where high value agro-horticultural activities have huge role to play in driving the economic growth

besides tourism, hydro-electric energy, wellness sector etc. The favorable agro-climatic conditions, by default organic cultivation practiced by farming communities, opening of international border huts at different locations of across NE states and ongoing activities of proposed South-East Corridor are expected to open a huge opportunities for agrarian communities in international trade and investment. North East is rich in diverse ago-horticultural produces especially many high value horticultural crops which have huge demand in other parts of the country and also beyond national boundary. King chill, turmeric, large cardamom, kiwi, passion fruit, plum, peach, pear, grapes, pineapple, jackfruit, orchids, flowers (rose, anthurium, gerbera, lilium, gladiolus, tuberose etc.) are some of the important high value crops to name. Some of these crops like king chilli (grown in Nagaland, Manipur, Assam. Arunachal P) and Kiwi (grown in Arunachal P) are exclusive to the region whereas other high value crops have either the ability for offseason supply to Indian metros (like grape of Mizoram) or have the qualitative edge (like queen pineapple of Tripura, lakadong turmeric of Meghalaya) over their competitors in the domestic as well as international markets.

1.4.2. Schemes with Differential Benefits for NE

There are several central sector schemes (Table 1) either run by the Ministry of Food Processing Industries, Ministry of Agriculture and Farmers Welfare, GoI and other government departments to promote food processing sector in India.

Table 1: List of Major Government Schemes for Development of FPI in India

Schemes	Aim of the Schemes	Pattern of Assistance
1. MoFPI Schemes- PMKSY- Total Rs. 6000 Crores allotment		
a. Mega Food Parks	To provide infrastructure through establishment of Collection Centres, Primary Processing Centres, Central Processing Centre.	Grant @ 50% (75% in NE Region) of the capital cost excluding land, subject to max. 50 Crores to Promoters.
b. Integrated Cold Chain & value Addition Infrastructure	To provide integrated cold chain and preservation infrastructure facilities.	Grant @ 35% in general areas (50% in NE Region) for cold chain infrastructure and @ 50% in general areas (75% in NE Region) for processing and irradiation facilities subject to max. Rs.10 Crores.
c. Creation/ expansion of food processing and preservation capacities	To provide processing and preservation infrastructure	Grant @ 35% in general areas (50% in NE Region) for plant, machinery and technical civil works up to max 5 cr.
d. Infrastructure for agro-processing clusters	To provide enabling and core infrastructure/ common facilities etc.	Enabling infrastructures like plots, boundary wall, drainage, water supply. Electricity supply, roads, effluent treatment plant, office area, etc. and core infrastructure like boilers, cold stores, warehouses, testing laboratories, primary processing facilities, etc. Grant @ 35% (50% in NE Region) maximum up to 10 Cr.
e. Creation of backward and forward linkages	To provide storing and transportation infrastructure	Grant @ 35% in general areas (50% in NE Region) maximum 5 Cr for reefer and refrigerated vans, CAS and MAP storing and packaging facilities, drying, and primary processing facilities.
f. Food safety and quality assurance infrastructure	To develop laboratory infrastructure and purchase & installation of equipment.	Grant @ 100 % for Govt. institutions and 50% in general areas (70% in NE Region) for laboratory infrastructure . Grant @ 50% in general areas (75% in NE Region)

		for implementation of HACCP, ISO and other certification
g. Human resources and institutions	To promote human resource development and R&D activities.	100% grant to govt. institutions for R&D projects and 50% grant (70% in NE) to private universities and institutions.
2. KVIC Schemes		
a. Prime Minister Employment Generation Program (PMEGP)	To assist in establishment of micro food processing units through credit link subsidy program	Credit subsidy @ 25% in rural & 15% in urban with 10% promoter's contribution (35% in rural & 25% in urban with 5% promoter's contribution for NE Region) subject to max 25 lakhs-manufacturing entreprise & 10 lakhs-service sector enterprise
b. In-House Test Laboratory	To create testing facilities for analysis of raw materials & products for establishing standards.	Financial assistance is 90% of the cost or Rs. 2.20 lakhs.
3. APEDA Schemes		
a. Infrastructure Development	To assist in development of pre-processing infrastructure.	For mechanized handling/pre-cooling/cold storage/ controlled atmosphere/ modified atmosphere storage etc. 25% equipment cost subject to max. Rs.10 Lakhs,
b. Packaging Development	To improve packaging standards.	Assistance to registered exporters @ 25% of total packaging cost subject to max. Rs 5 lakh
c. Export Promotion and Market Development	To assist in publicity and market development.	Supply of product literature, website dev., advert. etc. for market promotion in fairs/events organized/sponsored by APEDA.
4. SFAC Schemes		
a. Equity Grant And Credit Guarantee Fund Scheme	To enhance shareholding & ownership of FPC members, and increase credit worthiness, viability and sustainability of FPCs	Equity Grant shall be a cash infusion equivalent to the amount of shareholder equity in the FPC subject to a cap of Rs. 10 lakh per FPC
b. Venture Capital Assistance Scheme	To facilitate setting up of agribusiness ventures in close association with all Notified Financial Institutions notified by RBI (such as Nationalized banks, SBI & its subsidiaries, IDBI, SIDBI, NABARD, NCDC, NEDFi, Exim Bank, RRBs & State Financial Corporations) where the ownership of the Central/State Government is more than 50%	SFAC would provide venture capital to agribusiness projects by way of soft loan to supplement the financial gap worked out by the sanctioning authority of term loan under Means of Finance with respect to cost of project. The quantum of SFAC Venture Capital Assistance will depend on the project cost and will be the lowest of the following: ‹ 26% of the promoter's equity Rs. 50.00 lakhs.
c. Farmer Producer Organization Scheme	To promote economically viable, democratic, and self governing Farmer Producer Organisations (FPOs). To provide support for the promotion of such FPOs by qualified and experienced Resource Institutions	Assistance for cluster identification, diagnostic study, feasibility analysis, baseline assessment, business planning, mobilization of farmers, organizing and formalizing, resource mobilization, Systems development, business operations and assessment and audit.
5. Ministry of Agriculture & Farmers Welfare Scheme		
a. Mission Organic Value Chain Development for NE Region	To develop crop commodity specific organic value chain and address gaps in organic crop production, wild crop harvesting, organic livestock management and processing handling and marketing of organic agricultural products	Assistance for organic clusters development through Farmer Producer Organizations/ Companies, on-farm & off-farm input production, support extension services; value chain development through setting up of integrated processing units, pack house, storage and transport facilities, cold chain etc; value chain marketing through branding, certification, packaging, labeling; and setting up of value chain support agencies for surveys, certification, market research and consultancy.

Source: Websites of Ministry of Food Processing Industries (MoFPI), Govt. of India; Khadi and Village Industries Commission (KVIC), Govt. of India and Agricultural and Processed Food Export Development Authority (APEDA), Govt. of India, SFAC and Ministry of Agriculture and Farmers Welfare, GoI.

1.4.3. Area and Production in NE

The state wise area and production of total horticultural crops in NE during 2011-12 to 2017-18 is given in the Table 2. It clearly shows that in absolute terms both area and production of total horticultural crops in NE has increased from 1253.84 thousand ha in 2011-12 to 1473.84 thousand ha in 2017-18 and 10133.66 thousand MT in 2011-12 to 12693.13 thousand MT in 2017-18 respectively. The average annual growth rate (AAGR) of area and production of total horticultural crops in NE during 2011-12 to 2017-18 has increased at 2.75 per cent and 4.17 per cent respectively. Among the states, in area Manipur recorded the highest AAGR (7.82%) followed by Nagaland (5.39%) and Mizoram (4.43%) whereas in production Nagaland recorded the highest AAGR (12.91%) followed by Manipur (6.44%) and Meghalaya (5.75%). However, in both area and production Arunachal Pradesh recorded negative AAGR during 2011-12 to 2017-18. Further, the AAGR in both area and production of total horticultural crops in NE were higher than the all India levels.

The analysis of different sub sectors of horticulture shows that both area and production of fruit crops in absolute terms in NE have increased from 454.93 thousand ha in 2011-12 to 482.29 thousand ha in 2017-18 and 4157.11 thousand MT in 2011-12 to 4866.97 thousand MT in 2017-18 respectively (Table 3). The average annual growth rate (AAGR) of area and production of total fruit crops in NE during 2011-12 to 2017-18 has increased at 1.11 per cent and 2.89 per cent respectively. Among the states, in area under fruit crops Mizoram recorded the highest AAGR (6.64%) followed by Sikkim (5.46%) and Nagaland (2.81%) whereas in production Meghalaya recorded the highest AAGR (6.71%) followed by Assam (4.99%) and Manipur (4.69%). However, in both area and production of fruits Arunachal Pradesh recorded negative AAGR during 2011-12 to 2017-18. Further, the AAGR in both area and production of total fruits in NE were higher than the all India levels.

The area of vegetable crops in NE has increased at 4.06 per cent AAGR from 462.32 thousand ha in 2011-12 to 586.56 thousand ha in 2017-18 and the production has increased at 6.20 per cent AAGR from 4838.32 thousand MT in 2011-12 to 6664.24 thousand MT in 2017-18 respectively (Table 4). Amongst states, in area under vegetable crops Manipur recorded the highest AAGR (20.78%) followed by Nagaland (8.00%) and Tripura (5.89%) whereas in production Nagaland recorded the highest AAGR (24.07%) followed by Manipur (10.67%) and Sikkim (10.43%). The AAGR in both area and production of total vegetable crops in NE were higher than the all India levels.

The analysis of spices sector shows that the area under spices crops in NE has increased at 4.02 per cent AAGR from 190.89 thousand ha in 2011-12 to 241.13 thousand ha in 2017-18 and the production has increased at 3.05 per cent AAGR from 648.72 thousand MT in 2011-12 to 766.28 thousand MT in 2017-18 respectively (Table 5). Amongst states, in area under spices crops Nagaland recorded the highest AAGR (9.96%) followed by Sikkim (5.81%) and Assam (4.65%) whereas in production Nagaland recorded the highest AAGR (32.19%) followed by Sikkim

(3.74%) and Meghalaya (3.72%). The AAGR in both area and production of total spices in NE were higher than the all India levels.

The plantation crops sector shows that the area in NE has increased marginally at 1.59 per cent AAGR from 138.98 thousand ha in 2011-12 to 152.09 thousand ha in 2017-18 whereas the production has actually decreased at -6.43 per cent AAGR from 354.33 thousand MT in 2011-12 to 274.71 thousand MT in 2017-18 respectively (Table 6). Amongst states, in area under plantation crops Mizoram recorded the highest AAGR (17.21%) followed by Nagaland (16.07%) and Meghalaya (2.11%) whereas in production Nagaland recorded the highest AAGR (105.90%) followed by Meghalaya (2.57 %). The negative growth rate in production of plantation crops in NE is mainly because of decreasing production in Assam, Tripura, Mizoram and also non availability of data from AP, Manipur and Sikkim.

1.4.4. Prospects in Meghalaya

Meghalaya is basically an agrarian economy where 80 per cent population depends on agriculture for livelihoods by cultivating around 10 per cent of the total geographical area. Though the contribution of agriculture to total GDP is very low as compared to mining and tourism sectors, agriculture possess great relevance in terms of livelihood and income generation for the majority of the state's population. The favorable agro-climatic conditions of Meghalaya has suited the production of diverse agro-horticultural crops especially high value fruits and spices that can really generate significant income and employment in state's economy. Interestingly, the production of fruit crops in Meghalaya has significantly increased from 300.42 thousand MT in 2011-12 to 443.02 thousand MT in 2017-18. In production of fruit crops Meghalaya recorded the highest AAGR of 6.71 per cent followed by Assam (4.99%) and Manipur (4.69%) during the period. The cultivated area under fruit crops also increased at 1.64 per cent AAGR from 32.31 thousand ha in 2011-12 to 35.50 thousand ha in 2017-18. Production of vegetables also significantly increased at AAGR of 5.74 per cent from 385.01 thousand MT in 2011-12 to 522.55 thousand MT in 2017-18. In spices production, Meghalaya maintained a healthy AAGR of 3.72 per cent by increasing its production from 74.82 thousand MT in 2011-12 to 92.62 thousand MT in 2017-18. Overall, the area under horticulture has increased at 2.59 per cent AAGR from 111.23 thousand ha in 2011-12 to 129.46 thousand ha in 2017-18 whereas the total horticultural production has increased at 5.75 per cent AAGR from 789.08 thousand MT in 2011-12 to 1091.99 thousand MT in 2017-18. The major important agro-horticultural crops in the state are rice, maize, pineapple, banana, strawberry, turmeric, ginger, black pepper, long pepper, bay leaf, cinnamon, tomato, potato, squash and many vegetables. Interestingly, some of these crops like turmeric, pineapple, strawberry, ginger, black pepper has high demand in other parts of the country. Therefore, the state can accelerate its economic growth and development by developing sustainable value chain and entrepreneurship across potential clusters in the state.

In the ensuing chapter comprehensive information on the value addition options for each of these important agro-horticultural crops are given along with the associated preservation, packaging and machinery requirements. However, it not necessary to include all these value addition options in the value chain development process. The development of sustainable value chain model in fact depends on many factors which need to be taken care of for successful value chain and entrepreneurship evolution in any area. A detailed account of these factors is given in the last chapter.

Table 2: State wise Area and Production of Total Horticultural Crops for the Last Seven Years (Area in '000 Ha & Production in '000 MT)

States	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18		AAGR (%)	
	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P
AP	107.87	563.14	103.72	523.26	106.83	532.14	107.04	547.72	83.23	417.41	62.46	208.70	62.97	210.15	-7.84	-12.59
Assam	596.32	5427.05	626.02	5971.45	624.31	5546.26	639.76	7115.21	671.68	6481.49	664.42	5913.97	710.44	7044.11	3.00	5.44
Manipur	80.77	630.31	84.13	684.55	91.37	812.66	97.13	814.17	97.02	808.95	121.43	872.39	124.80	906.84	7.82	6.44
Meghalaya	111.23	789.08	113.58	823.94	122.07	978.99	124.10	1027.06	127.89	1014.07	131.01	1075.93	129.46	1091.99	2.59	5.75
Mizoram	106.93	626.30	120.26	761.16	130.03	835.75	139.68	882.20	137.44	586.97	137.42	625.02	137.67	628.40	4.43	1.74
Nagaland	77.62	611.07	74.54	533.37	90.56	954.24	91.06	954.33	96.98	995.05	103.57	1069.92	104.55	1063.96	5.39	12.91
Sikkim	63.01	230.48	67.00	243.11	74.43	232.26	63.49	209.86	67.48	212.10	76.58	299.80	77.33	298.80	3.91	5.58
Tripura	110.09	1256.23	126.18	1503.49	136.57	1617.11	141.95	1680.22	144.07	1698.56	123.77	1431.50	126.62	1448.88	2.75	2.95
NE	1253.84	10133.66	1315.43	11044.33	1376.17	11509.41	1404.21	13230.77	1425.79	12214.6	1420.66	11497.23	1473.84	12693.13	2.75	4.17
All India	**23241.97**	**257277.15**	**23694.14**	**268847.45**	**24198.48**	**277352.04**	**23410.00**	**280986.11**	**24471.67**	**286187.72**	**24850.86**	**300642.95**	**24915.88**	**305426.30**	1.19	2.91

Source: National Horticulture Board, GoI.
Note: A = Area, P= Production and AAGR = Average Annual Growth Rate.

Table 3: State wise Area and Production of Fruit Crops for the Last Seven Years (Area in '000 Ha & Production in '000 MT)

States	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18		AAGR (%)	
	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P
AP	85.11	308.86	86.86	312.24	89.09	321.26	90.00	331.40	66.21	306.27	48.71	124.38	49.15	125.34	-7.72	-9.84
Assam	142.76	1851.77	150.71	2073.82	144.68	2007.8	145.21	2030.14	145.71	2077.77	142.89	2024.84	163.99	2433.95	2.52	4.99
Manipur	49.47	405.85	51.93	440.59	54.05	515.69	55.62	521.57	51.12	467.76	50.58	478.76	54.93	523.61	1.90	4.69
Meghalaya	32.31	300.42	33.15	316.57	35.30	348.00	36.33	377.25	36.59	395.40	37.37	426.86	35.50	443.02	1.64	6.71
Mizoram	43.68	275.71	49.68	292.95	57.55	343.90	60.27	350.91	55.01	330.28	62.56	339.05	62.89	342.04	6.64	3.89
Nagaland	33.70	347.68	37.23	275.95	40.56	411.00	40.56	411.00	37.05	374.13	39.19	388.49	39.32	380.30	2.81	3.51
Sikkim	13.40	22.47	14.65	24.02	16.02	24.05	16.02	24.05	17.53	23.48	18.55	25.56	18.33	24.01	5.46	1.24
Tripura	54.50	644.35	60.12	697.87	68.38	786.35	71.77	819.12	75.74	854.05	57.84	559.92	58.18	594.70	1.92	0.20
NE	**454.93**	**4157.11**	**484.33**	**4434.01**	**505.63**	**4758.05**	**515.78**	**4865.44**	**484.96**	**4829.14**	**457.69**	**4367.86**	**482.29**	**4866.97**	**1.11**	**2.89**
All India	**6704.17**	**76424.21**	**6982.02**	**81285.33**	**7216.31**	**88977.13**	**6109.67**	**86601.68**	**6300.67**	**90183.04**	**6373.39**	**92918.04**	**6428.48**	**94883.86**	**-0.45**	**3.74**

Source: National Horticulture Board, GoI.
Note: A = Area, P= Production and AAGR = Average Annual Growth Rate.

Table 4: State wise Area and Production of Vegetable Crops for the Last Seven Years (Area in '000 Ha & Production in '000 MT)

States	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18		AAGR (%)	
	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P
AP	6.34	83.50	1.52	37.56	1.40	35.00	1.70	41.00	4.00	33.01	1.75	14.42	1.77	14.57	2.95	-19.91
Assam	266.00	3045.56	278.74	3415.07	281.4	3031.90	289.26	4469.73	317.59	3821.71	300.75	3329.58	320.70	4033.30	3.28	7.02
Manipur	20.83	200.32	21.73	219.82	25.19	271.04	29.33	268.01	34.36	316.51	59.40	369.86	58.21	359.30	20.78	10.67
Meghalaya	39.46	385.01	40.45	403.37	43.60	515.34	44.60	534.00	47.50	494.88	49.50	523.42	49.73	522.55	3.96	5.74
Mizoram	37.42	221.10	39.33	236.68	41.10	254.14	44.03	273.76	45.21	179.02	37.02	179.88	36.98	179.86	0.20	-2.00
Nagaland	33.04	222.63	26.01	207.74	38.55	492.37	38.55	492.37	43.53	494.61	47.17	564.62	47.06	561.57	8.00	24.07
Sikkim	25.03	127.65	25.56	132.51	26.11	134.53	29.15	130.06	20.25	106.94	25.54	190.72	25.54	190.72	1.92	10.43
Tripura	34.20	552.55	45.10	754.05	46.69	780.52	48.61	811.09	46.48	793.24	46.68	817.94	46.57	802.37	5.89	7.15
NE	**462.32**	**4838.32**	**478.44**	**5406.8**	**504.04**	**5514.84**	**525.23**	**7020.02**	**558.92**	**6239.92**	**567.81**	**5990.44**	**586.56**	**6664.24**	**4.06**	**6.20**
All India	**8989.54**	**156325.48**	**9205.19**	**162186.57**	**9396.06**	**162896.91**	**9542.23**	**169478.23**	**10106.29**	**169063.93**	**10237.93**	**178172.41**	**10172.41**	**180684.15**	**2.10**	**2.46**

Source: National Horticulture Board, GoI.
Note: A = Area, P= Production and AAGR = Average Annual Growth Rate.

Table 5: State wise Area and Production of Spices Crops for the Last Seven Years (Area '000 Ha & Production '000 MT)

States	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18		AAGR (%)	
	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P
AP	10.05	61.60	10.17	64.27	10.17	64.27	10.17	64.27	11.44	68.72	11.44	68.72	11.50	69.06	2.37	1.96
Assam	93.05	261.56	96.66	287.5	93.08	279.14	98.6	321.03	100.53	333.69	119.99	291.3	120.59	292.76	4.65	2.29
Manipur	10.47	24.14	10.47	24.14	10.47	24.14	10.47	24.14	10.47	24.14	10.47	23.14	10.52	23.26	0.08	-0.60
Meghalaya	16.84	74.82	16.85	74.81	17.50	83.88	17.50	83.88	18.37	90.26	18.61	92.16	18.70	92.62	1.78	3.72
Mizoram	20.65	114.98	22.47	59.62	22.47	59.62	23.30	65.72	24.57	68.89	24.81	97.20	24.93	97.69	3.24	1.42
Nagaland	9.77	39.17	9.77	39.16	9.77	39.16	9.77	39.16	15.00	119.25	15.69	105.00	15.95	105.62	9.96	32.19
Sikkim	24.38	54.41	26.56	60.08	32.06	55.80	34.08	61.14	29.46	64.78	32.25	66.58	33.22	67.14	5.81	3.74
Tripura	5.68	18.04	5.69	18.04	5.69	18.04	5.69	18.04	5.69	18.04	5.69	18.04	5.72	18.13	0.12	0.08
NE	**190.89**	**648.72**	**198.64**	**627.62**	**201.21**	**624.05**	**209.58**	**677.38**	**215.53**	**787.77**	**238.95**	**762.14**	**241.13**	**766.28**	**4.02**	**3.05**
All India	**3212.47**	**5951.46**	**3075.9**	**5743.52**	**3163.24**	**5908.29**	**3317.28**	**6108.28**	**3473.53**	**6988.47**	**3535.4**	**7077.30**	**3692.65**	**8163.32**	**2.40**	**5.63**

Source: National Horticulture Board, GoI.
Note: A = Area, P= Production and AAGR = Average Annual Growth Rate.

Table 6: State wise Area & Production of Plantation Crops for the Seven Years (Area '000 Ha & Production '000 MT)

States	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18		AAGR (%)	
	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P
AP	0.00	0.00	0.00	0.00	1.00	0.56	0.00	0.00	1.09	8.33	0.07	0.10	0.07	0.10	-	-
Assam	94.52	268.16	98.11	183.36	97.8	174.56	98.76	238.06	98.4	167.03	91.33	177.72	95.50	190.64	0.25	-8.6
Manipur	0.00	0.00	0.00	0.00	0.90	1.50	0.90	0.15	0.90	0.32	0.90	0.32	0.90	0.32	-	-
Meghalaya	22.62	28.83	23.12	29.19	25.61	29.40	25.61	29.18	25.37	31.2	25.52	32.96	25.52	33.25	2.11	2.57
Mizoram	5.03	14.45	7.59	4.38	7.60	4.40	10.78	7.38	10.77	7.38	11.90	7.38	11.90	7.38	17.21	-4.56
Nagaland	1.10	1.60	1.52	10.52	1.67	11.35	2.17	11.55	1.22	4.68	1.36	4.68	2.05	9.34	16.07	105.9
Sikkim	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
Tripura	15.71	41.29	15.27	33.53	15.81	32.20	15.88	31.97	16.15	33.23	13.56	35.60	16.15	33.68	0.99	-2.77
NE	**138.98**	**354.33**	**145.61**	**260.98**	**150.39**	**253.97**	**154.10**	**318.29**	**153.90**	**252.17**	**144.64**	**258.76**	**152.09**	**274.71**	**1.59**	**-6.43**
All India	**3576.53**	**16358.68**	**3641.14**	**16984.6**	**3674.6**	**16301.22**	**3533.54**	**15574.83**	**3679.67**	**16658.29**	**3598.00**	**17972.03**	**3664.26**	**18052.7**	**0.44**	**1.88**

Source: National Horticulture Board, GoI.

Note: A = Area, P= Production and AAGR = Average Annual Growth Rate.

2. Processing, Value Addition, Preservation and Packaging Prospects of Important Agro-horticultural Crops of Meghalaya

2.1. Ginger

2.1.1. Introduction

Fig 1: Ginger

The Ginger or Adrak is the dried underground stem or rhizome of the Zingiberous herbaceous plant. Ginger is obtained from the rhizomes of *Zingiber officinale* plant. Ginger is harvested by digging out the rhizomes when the tops have died down. The main origin of ginger is South East Asia (India), and China. The name ―Zingiber is derived from Sanskrit name - Sringabera means – Horn-shaped. In Chinese ginger is called ―Kiang. Ginger has a distinct spicy flavor and used as a major spice in Indian foods. Ginger is popular not only for its flavor but also for its several medicinal values. It is useful for laxative effect, indigestion, asthma, bronchitis and also acts as an appetizer. Fresh ginger is effective in cold and coughs as well as in diabetics. Among all spices, ginger is the main cash crop supporting the livelihood of many ginger growers of north eastern region especially Meghalay. Ginger is grown in almost all the states of the region but the leading states are Meghalaya, Mizoram, Arunachal Pradesh and Sikkim. Ginger is a seasonal product but it is used extensively in many food preparations. Therefore, it is essential to convert a part of produce into different value added products to make the crop remunerative.

2.1.2. Chemical Composition of Ginger

Table 7: Chemical composition of Ginger

Chemical compounds	Content (%)
Moisture	80.9
Fat	0.9
Protein	2.3
Ash	1.2
Carbohydrate	12.3
Fiber	2.4
Vitamin C	6 mg/100 g
Thiamin	0.06 mg/100 g
Niacin	0.6 mg/100 g
Calcium	20 mg/100 g
Phosphorus	60 mg/100 g

2.1.3. Primary Processing and Value Added Products form Ginger

2.1.3.1. Dehydrated Ginger Slices

Raw Materials: Matured ginger, lime (Calcium oxide), purified water.

Process Flow

1. Selection of fresh ginger rhizomes
2. Washing to remove the adhering impurities
3. Peeling/treating in lime water solution (rhizomes are steeped in a solution of 1.5 to 2.0% lime (calcium oxide) for 6 hours, and then drained. This is done to improve the appearance of the slices.)
4. Slicing (by electrical slicer)
5. Drying (at 55-60° C up to 10 % moisture content)
6. Packaging
7. Storage

Fig 2: Dehydrated Ginger Slices

2.1.3.2. Salted Ginger

Raw Materials: Soft ginger rhizomes, salt, and lemon juice.

Process Flow

1. Selection of fresh ginger rhizomes
2. Washing to remove the adhering impurities
3. Peeling
4. Slicing (by electrical slicer) or dicing or cutting into strips
5. Boiling 2-3 times (10-15 min) by changing water (to reduce hotness)
6. Mixing with 2- 4 % dry salt and lemon juice (50 ml/kg slices) and keeping for 2-3 hrs
7. Draining of water
8. Drying (at 55-60° C upto 10 % moisture content)
9. Packaging
10. Storage

Fig 3: Salted Ginger

Final Product Quality:

- The color of the ginger slices will be bleached with a light pink color.
- The taste will be salty and sour.

- Final moisture content should not go above 10%

2.1.3.3. Ginger Powder

Raw Materials: Dried ginger slices.

Process Flow

1. Process the dry ginger as per previous procedure. Then make it into fine powder by suitable pulverizer with various changeable mesh sizes. Moisture content of the powder should be less than 10%

Fig 4: Ginger Powder

Machineries and Packaging Materials
(Dehydrated ginger slices, Salted ginger, Ginger powder)

Machineries	**Packaging Materials**
Ginger peeling unit Washing unit Slicer, dicer, and strip cutter Blanching unit Tray dryer Spice grinding machine Pouch sealing machine (semiautomatic or automatic)	 Fig 5. Poly Ethylene/ Poly Propylene pouch/Laminated Poly Propylene

Fig 6: Ginger peeling and washing machine

Fig 7: Slicer, Dicer, Shredder

Fig 8: Tray dryer

Fig 9: Blanching machine

Fig 10: Spice grinder

Fig 11: Automatic form fill seal machine

2.1.3.4.Ginger Oil Distillation

Raw Materials: Fresh or dried rhizomes

Process Flow

Ginger oil can be produced from fresh or dried rhizomes. Oil from the dried rhizomes will contain fewer of the low boiling point volatile compounds (the compounds that give ginger its flavour and aroma) as these will have evaporated during the drying process. The best ginger oil is obtained from whole rhizomes that are unpeeled.

Ginger oil is obtained using a process of steam distillation. The dried rhizomes are ground to a coarse powder and loaded into a still. Steam is passed through the powder, which extracts the volatile oil components. The steam is then condensed with cold water. As the steam condenses, the oils separate out of the steam water and can be collected. In India the material is re-distilled to get the maximum yield of oil. The yield of oil from dried ginger rhizomes is between 1.5 to 3.0%. The remaining rhizome powder contains about 50% starch and can be used for animal feed. It is sometimes dried and ground to make an inferior spice.

Machineries and Packaging Materials

Machineries	Packaging Materials
Ginger oil distillation unit	

Fig 12: Glass bottles or tubes

2.1.3.5. Sweet Ginger Candy

Raw Materials: Soft ginger rhizomes, sugar.

Process Flow

1. Select soft ginger rhizomes
2. Wash and peel
3. Slice into desirable sizes
4. Boil 2 – 3 times by changing the water. It is to remove the excessive hotness of the ginger and to make the slices softer

5. Weigh the sugar (60 % of the weight of the ginger) and grind it into fine powder
6. Mix the powdered sugar with the ginger slices and keep it for overnight in cool and dry place
7. The water will come out from the ginger slices and dissolve the sugar.
8. Cook the ginger slices with the sugar syrup until it becomes dry and the sugar of the syrup again get crystallized.
9. Cool, pack, and seal
10. Store in a dry and cool place

Fig 13: Sweet Ginger Candy

Machineries and Packaging Materials

Machineries
Ginger peeling unit
Washing unit
Slicer, dicer, and strip cutter
Blanching unit
Tray dryer
Steam jacketed syrup processing machine
Boiler
Semi automatic pouch sealing machine

Packaging Material
PE/PP/Laminated PP
PET jars
Glass jars

Fig 14: Poly Propylene (PP) packet

Fig 15: Steam jacketed kettle for syrup

Fig 16: Boiler

Fig 17: Pouch Sealing Machine

Fig 18: PET Jars

Fig 19: Glass Jars

2.1.3.6. Ginger RTS

Raw Materials: Raw ginger, sugar, Citric acid, water.

Process Flow

1. Extraction of Ginger Juice
2. Washing of raw ginger rhizomes
3. Peeling
4. Grating
5. Addition of water (1 part ginger : 2 parts of water)
6. Grinding
7. Straining
8. Keeping 1 hour for settling
9. Siphoning of clear juice
10. Straining
11. Juice
12. Mix strained sugar syrup (sugar + water + acid, heated just to dissolve) with jiuce
13. Homogenization

13.a Bottling
Crown corking
Pasteurization (90 ° C for 15 min)
Cooling and storage

or

13b. Pasteurization
Cooling
Adding preservative (SB – 120 ppm)
Bottling and storage

Fig 20: Ginger RTS

FPO Specification for Ginger RTS

Min amount of ginger juice	2.5%
TSS	10%
Acidity	0.3%

Machineries and Packaging Materials:

Machineries	**Packaging Material**
Ginger peeling unit	Glass bottles
Washing unit	Pet bottles
Ginger grater	
Blanching unit	
Steam jacketed kettle	
Syrup preparation tank	
Settling tank	
Homogenizer	
Juice pasteurizer	
Juice filling/bottling unit (Semiautomatic/automatic)	
Chilling tank	
Boiler	

Fig 21: Ginger RTS/Juice Pasteurizer

Fig 22: Filling/Bottling Unit for RTS/Juice

Fig 23: Homogenizer

Fig 24: PET Bottles

2.2. Turmeric

2.2.1. Introduction

Fig 25: Turmeric

Turmeric *(Curcuma domestica)* is an erect perennial plant grown as an annual crop for its rhizome (underground root like stem bearing roots and shoots). It belongs to the same family as ginger (*Zingiberaceae)* and grows in the same hot and humid tropical climate. The rhizome is a deep bright yellow colour and similar form to the ginger but slightly smaller. The rhizome of turmeric *(Curcuma longa L.)* has a rich history in India as spice, food preservative, and coloring agent and has been used for centuries in the Ayurvedic system of medicine. The spice is sometimes referred to as 'Indian saffron'. Long before the time of cheaper synthetic food preservatives and colouring agents, spices like turmeric played a key role as food additive. Its use as a remedy for hypercholesterolemia, arthritis, indigestion and liver problem has been known since long. The continuing research indicates that turmeric and its active principle curcumin have unique antioxidant, antimutagenic, antitumorigenic, and anticarcinogenic, antiinflammatory, antiarthritic, antimicrobial, and hypocholesterolemic properties as reviewed elsewhere

2.2.2. Chemical Composition

The general composition of turmeric is given in Table 6.2. Turmeric contains protein (6.3%), fat (5.1%), minerals (3.5%), carbohydrates (69.4%) and moisture (13.1%). The rhizomes contain curcuminoids (2.5–6%) and are responsible for the yellow colour. Curcumin (diferuloylmethane) comprises Curcumin I (curcumin), Curcumin II (demethoxycurcumin) and Curcumin III (bisdemethoxycurcumin), which are found to be natural antioxidants (Ruby et al., 1995). A new curcuminoid, cyclocurcumin, has been isolated from the nematocidally active fraction of turmeric. The fresh rhizomes also contain two new natural phenolics, which possess antioxidant and anti-inflammatory activities, and also two new pigments. The essential oil (5.8%) obtained by steam distillation of rhizomes has α-phellandrene (1%), sabinene (0.6%), cineol (1%), borneol (0.5%), zingiberene (25%) and sesquiterpines (53%) (Kapoor, 1990).

2.2.3. Primary Processing and Value Added Products form Turmeric

2.2.3.1. Dehydrated Turmeric

Raw Materials: Raw turmeric rizhomes.

Process Flow

1. **Cleaning and sorting:** Cleaning of rhizomes to remove soil, leaves and other foreign materials and separation of fingers.
2. **Slicing (Optional):** Slicing can be done to reduce drying time and when it is aimed for powdering
3. **Curing (Boiling in water):** Boiled / steamed to remove raw odor & reduce drying time, gelatinize starch & produce uniform colored product.
4. **Drying:** Drying of fingers under sun or in electric tray dryer.
5. **Polishing:** The dried rhizomes are polished to remove the scales and root bits.
6. **Packaging:** Polished rhizomes are packed and stored for further processing or marketing.

Fig 26: Dehydrated Turmeric

2.2.3.2. Turmeric Powder

Raw Materials: Dehydrated turmeric.

Process Flow

1. Raw Turmeric
2. Washing
3. Curing (Boiling in water for 45 min, add 0.05% to 1.0% sodium carbonate or lime (calcium carbonate))
4. Slicing (to reduce drying time. Otherwise whole rhizomes also can be dried)
5. Drying (60°C up to moisture contentment less than 10 %)
6. Grading
7. Polishing (for whole turmeric)
8. Grinding & Sieving (300 & 500 micron)
9. Packing (moisture & UV light proof PM)
10. Storage (Free from Direct Sunlight)

Fig 27: Turmeric Powder

2.2.3.3. Turmeric Oleoresin

The selection of a turmeric oleoresin of a particular composition is based on the intended use in food. In general, all turmeric oleoresins contain colouring matter and most contain flavouring matter but some oleoresins are processed to remove aromatic compounds. Commercial products include oleoresins (per se) and formulations in which oleoresin is diluted in carrier solvents and

which may contain emulsifiers and antioxidants. Purified extracts of turmeric containing more than 90% total colouring matter are subject to specifications for "Curcumin".

Turmeric Oleoresins are sold on the basis of "colour value" or "curcumin content", which generally means the total content of the curcuminoids which comprises of: diferuloylmethane (Curcumin I), demethoxycurcumin (curcumin II), bisdemethoxycurcumin (curcumin III), and the recently identified cyclocurcumin.

Use of Curcumin

Curcumin is an ingredient of turmeric which is found in limited amounts in ginger. It is a cancer preventive molecule and is anti-inflammatory. It is extracted from turmeric and is widely used in pharmaceuticals, food and cosmetics industry for its anti-oxidation and anti-inflammatory properties. Curcumin is used in the treatment of tumors, arthritis, gastric ailments and viral infections. Rising consumer awareness towards health benefits of curcumin and growing demand for curcumin-based nutritional supplements due to increasing consumer awareness regarding its anti-cancer properties are the main drivers responsible for the growth of global curcumin market.

In terms of application, global curcumin market is categorized into pharmaceuticals, food, cosmetics and others. Pharmaceutical held the largest market share due to rising demand for curcumin based supplements. Increasing demand for herbal cosmetic products is expected to drive the global market of curcumin in cosmetic applications as it serves as a remedy for various skin diseases. Shifting consumer preference towards natural food coloring food substances is expected to increase the demand of curcumin in food applications. However, existence of cheap synthetic food colors serves as a restraining factor in the growth of curcumin market in Rest of the World (RoW) and Asia Pacific region.

On account of its therapeutic qualities, turmeric is a widely used ingredient in food and medical products, particularly in the Indian subcontinent. Over the past few years, there has been an increasing demand for ayurvedic medicinal formulations across the globe. It is the presence of curcumin that gives turmeric its unique therapeutic qualities.

Raw Materials: Dehydrated turmeric.

Process Flow

1. Preparation of turmeric powder (40-60 mesh size)
2. Treatment with solvents (Ethanol/acetone/water) for 2-3 hrs (Powder: solvent ratio 1:3)
3. Filtration
4. Distillation/ vacuum or low temperature evaporation of the solvent
5. Turmeric oil/ turmeric oleoresin
6. Bottling and sealing

Fig 28: Turmeric Oleoresin

Machineries and Packaging Materials

Machineries

Turmeric peeling unit
Washing unit
Slicer (motor driven)
Boiling unit (Gas/electric/steam driven)
Tray dryer
Milling machine
Pouch sealing machine (semiautomatic or automatic)

Packaging Materials

Fig 29:.Poly Ethylene/ Poly Propylene pouch/Laminated Poly Propylene

Fig 30: Turmeric peeling and washing machine

Fig 31: Turmeric Slicer, Dicer, Shredder

Fig 32: Tray dryer

Fig 33: Steam Jacketed Kettle for Boiling

Fig 34: Turmeric grinder

Fig 35: Automatic form fill seal machine

2.3. Pepper (Black, Green, White, and Long pepper)

2.3.1. Introduction

Fig 36: Black pepper and Long Pepper

Black Pepper (*Piper nigrum*), the king of spices, is one of the oldest and the most popular spices in the world. It is a perennial, climbing vine indigenous to the Malabar Coast of India. The hot pungent spice made from its berries is one of the earliest spices known in India. Black pepper is grown under a variety of agricultural schemes ranging from home gardens, mixed crops in coffee plantations and monocrops on slopes and in valleys. After almost three years, the plants are over 2 m tall and are bushy. They start flowering at the onset of rains. The fruits are picked by hand, and are harvested 6 to 8 times each season at two-week intervals. A long rainy season, fairly high temperatures, and partial shade are required for the best growth of plant. Different varieties of pepper available are Betel pepper (Piper betel), **Indian long pepper** (*Piper longum*), Java long pepper (Piper retrofractum), Rough leaved pepper (Piper amalago), etc. Pepper plant is a native of the Malabar Coast in Kerala. At present India accounts for more than 20% of the world output of pepper and is also one of the largest consumers and exporters of pepper. Kerala is the largest producer of pepper accounting for over 95% of India's total output. Pepper is cultivated in Kerala in Idukki, Kottayam, Cannanore, Calicut and Wayanad. Pepper is also cultivated in Karnataka, Tamil Nadu, A&N Islands and Pondicherry.

Long Pepper (*Piper longum*), sometimes called Indian long pepper (pipli), is a flowering vine in the family Piperaceae, cultivated for its fruit, which is usually dried and used as a spice and seasoning. Long pepper has a taste similar to, but hotter than, that of its close relative Piper nigrum – from which black, green and white pepper are obtained.

2.3.2. Processing Dehydrated Green Pepper

Dehydrated Green Pepper is prepared from immature green pepper fruits of suitable varieties by processing under controlled conditions. The fruits should be reasonably uniform in size having characteristic pungency, flavor and color of green pepper. Pepper fruits are blanched in boiling water for a few minutes, drained, cooled and then soaked in sulphur dioxide solution to fix the green color followed by drying in a cabinet drier at 50°C.

2.3.3. Processing of White Pepper

White Pepper is manufactured by one of the following techniques:

1. Water steeping and retting technique—either from ripened fresh berries or from dry berries
2. Steaming or boiling technique
3. Chemical technique and
4. Decortications technique.

Water Steeping Technique or Retting Process

The crop is harvested when one or two fruits in a spike start yellowing, thrashed and heaped in tanks through which water is allowed to run for 7 to 10 days. The light fractions of the pepper like pin heads and light berries which come to the surface are removed and the remaining mass is rolled over at least thrice a day during the retting stage. On the eleventh day the outer skin is removed by gentle rubbing and the de-skinned fruits are put in another tank containing bleaching solution. It is then allowed to stay in the bleaching solution for two days after which they are drained, washed and sun dried.

Boiling Technique

This technique, developed at the Central Food Technology Research Institute (CSIR), Mysore, India involve steaming or boiling the mature green fruits for 10–15 minutes. The outer skin of the fruits gets softened during the steaming process and is removed by passing through a pulping machine. The de-skinned fruits (seeds) are washed and treated with sulphur dioxide or bleaching powder solution after which they are washed and dried in the sun. The skin recovered from this process may be used for the recovery of pepper oil by steam distillation though it may not be economical.

2.3.4. Processing of Black Pepper

Harvesting

By definition, processing does not include harvesting. However one cannot produce a good product from badly harvested materials. The pepper spike should be harvested when one or more of the berries start going red. The berries should be hard to the touch. It is important that the spikes are harvested at the same stage of maturity as this ensures a more uniform final product.

Fermentation

The harvested spikes are kept in bags for 12–24 hours or heaped and covered overnight for a brief fermentation which makes de-spiking easy and also it allows an enzymatic reaction to proceed in which phenolic compounds are oxidized ensuring that the final product has a good black colour. The length of time that pepper is fermented varies from a few hours in Sri Lanka to a few days in Indonesia.

Threshing

The berries can be detached from the spike by hand or beating them with sticks. The larger pieces of the spike stem can then be picked out and smaller pieces removed using a winnowing basket. In some countries, such as Sri Lanka, threshing does not take place until after final drying. Mechanical threshers are used only by large growers

Washing

The berries should next be washed in clean, cold water. Berries which float are not suitable for culinary use anti should be dried separately. There is a market for these berries for oil distillation.

Blanching

Blanching is considered to increase the rate at which berries dry and also speed up the enzymatic reaction that produces the final desired black colour. Blanching is carried out by immersing the berries in hot, but not boiling, water for up to 10 minutes until their colour changes to a dark green. It is important that the pepper is not left in the water for more than 10 minutes as volatile flavour components can be lost and the enzymes responsible for the colour changes may be deactivated. A simple method of blanching involves placing the berries in a cloth sack attached to a stick. The sack can then be immersed and removed from the hot water with relative ease.

Drying

Drying is perhaps the most important step in the processing of pepper. It is advisable that the pepper is dried as quickly as possible because in the hot, humid climates where it is grown, mould growth can be rapid. Sun drying is the most common method of drying pepper for the small-scale producer. Otherwise some electric tray dryer or solar dryer operating below 70°C can be used. The pepper should be dried to a moisture content (wet basis) of not more than10 % .

Winnowing and Grading

Removing dust and dirt and grading the dried pepper berries can be carried out with winnowing baskets and sieves. Winnowing and grading machines are available for larger throughputs, but are usually not suitable for small-scale production.

Grinding

Grinding is done by any mechanical grinder/ pulverizer with suitable mesh size.

Packaging and Storage

Black pepper needs to be stored in air-tight containers to prevent moisture uptake or volatile flavour component loss. Polythene is unsuitable as the volatile flavour components are lost through the material, therefore, polypropylene/ laminated plastic material is required.

Machineries and Packaging Materials

Machineries	**Packaging Materials**
Pepper cleaning machine	PP/ Laminated PE
Blanching tank	(same as turmeric)
Tray dryer	
Winnowing machine	
Grading machine	
Milling machine	
Pouch sealing machine (Semi automatic/automatic)	

Fig 37: Tray Dryer for Pepper

Fig 38: Pepper cleaning machine

Fig 39: Pepper Grinder

Fig 40: Form Fill-Seal Machine for Powder

2.4. Chili

2.4.1. Introduction

Chilli (Capsicum annuumL.) is a spice cum condiment in Indian cuisine. It was discovered by Christopher Columbus when he landed in South America and India got the first taste of this pungent spice by the Portuguese explorer Vasco-da-Gama. Chilli is popularly known as capsicum, red pepper or paprika depending upon the species. They are used fresh and processed, dried whole, frozen and canned and as value added products like powder, oleoresin, capsanthin, chilli paste and chilli oil which are in vogue in the present global market. Chillies have long been used for pain relief as they are known to inhibit pain messengers, extracts of chilli peppers are used for alleviating the pain of arthritis, headaches, burns and neuralgia. It is also claimed that they have the power to boost immune system and lower cholesterol. They are also helpful in getting rid of parasites of gut.

Fig 41: Chili

2.4.2. Post Harvest Management of Chili

1. Judging of maturity: Chili is generally harvested when ripe, but it also can be harvested at a green, immature stage Maturity of green chili can be based on size, firmness, and color. For fruit to be harvested ripe, at least 50% color should have developed.
2. Harvesting: Harvesting can be done weekly, preferably during the early part of the day. If chili must be harvested when the sun is up, the fruit should place under shade to dissipate

heat before it is packed. Chili is picked by hand. The fruit is harvested by removing it from the branch and ensuring that the stem remains intact and attached to the fruit. Harvested fruits can be placed directly into plastic field crates or into smaller plastic buckets, which are then transferred to crates at the side of the field.

3. Field handling. The harvested fruit should be kept in shaded conditions, and protected from sun, wind, and rain. Plastic crates are recommended when transporting from the field to the packinghouse to minimize damage. Sacks or mesh bags do not provide sufficient protection for the fruit during transport.
4. Cleaning: Chili should be cleaned in the field. Clean chili by gently rubbing the fruit to remove debris and soil particles.
5. Sorting/Grading. Fruit with defects such as cracks, decay, mechanical damage, and sunburn should be sorted out and rejected. Undersized, shriveled, dull-looking, pitted, or softening fruit also should be rejected. Chili may be classified based on color, such as red, green, and a mixture of red, green, and yellow, and placed together or separate parts of the same container. Each class can be assigned a particular name (e.g. Class or Grade 1, Grade 2, and so on).
6. Packaging. Different kinds of packaging containers are used for chili for in domestic markets, including bamboo baskets, wooden crates, plastic crates, and plastic bags Plastic crates offer better protection against physical injuries than the other containers due to their smooth surface, rigidity, and ease in handling. If bamboo baskets or wooden crates are used, protective measures must be applied such as using liners (e.g. fresh leaves, old newspaper) and proper strapping or binding of the container.
7. Storage: If cold storage facilities are available, peppers can be stored at 10°C with 85-90% RH. The fruit can last for 2-3 weeks. Simple methods to maintain freshness and extend shelf life can be employed, such as modified atmosphere (MA) storage or packaging made from polymeric films, particularly commercially available products such as polyethylene and polypropylene bags.
8. Transport and Market Handling: Chili is susceptible to mechanical damage, particularly if transported in sacks or bags. At the market, keep chili dry. Do not allow rain or other moisture to collect on the fruit. Protect from dust and insects to ensure the fruit is wholesome and clean.

2.4.3. Processed Products from Chili

2.4.3.1. Green Chili in Brine

Raw Materials: Green chili 1 kg; vinegar 500 ml; 1000 ml boiled and cooled water; salt 135gm.

Process Flow

1. Preparing the brine solution
   (75g salt, 500ml water and 250ml vinegar)

2. Placed washed chillies in pre sterilized container
3. Addition of Brine solution
4. Keeping for 3-4 days in warm place
5. Discard the brine solution
6. Addition of fresh brine solution (boil) (60g salt)
7. Seal the lid
8. Place the jar in hot water for 85°C for 15 min

Fig 42: Green Chili in Brine

Packaging Materials

Big Glass jars / stainless steel drums can be used for storing

2.4.3.2. Chili Powder and Flakes

Raw Materials: Raw Red chilly/ Green chili

Process Flow

1. Washing
2. Removal stem
3. Drying (55°c for 24 hrs)
4. Dried chillies (moisture 8%)
5. Grinding/ flaking by Ball mill
6. Sieving
7. Packaging in laminated poly propylene bags
8. Labeling
9. Store in cool & dry place

Fig 43: Chili Powder

Fig 44: Chili Flakes

Machineries and Packaging Materials

Machineries	**Packaging Materials**
Washing tank	PP/LDPE
Blanching tank	Laminated PE
Tray dryer	
Dry chili grinding machine	(same as turmeric)
Chilly flaking machine	
Pouch filling machine (automatic/semiautomatic)	

Fig 45: Tray Dryer for Chili

Fig 46: Blanching Machine

Fig 47: Chili Grinder

Fig 48: Form Fill-Seal Machine for Powder

2.4.3.3. Chili Sauce

Raw Materials: Green chilly: 1 Kg; potato: 250 gm; sugar: 50 gm; salt: 50 gm; hot spices: 50 gm; glacial acetic acid: 8-10 ml

Process Flow

1. Take fresh green chilies (remove stems) and potato
2. Wash and peel the potatoes
3. Boil the chilly and potato
4. Mixing potato and chilly to make paste
5. Straining (to remove the seeds)
6. Add the hot spices by a spice bag and sugar
7. Cooking till desired consistency (8°Brix)
8. Addition of salt
9. Addition of acetic acid
10. Cool and add Sodium benzoate (1g/kg of final product)
11. Filling in sterilized glass bottles
12. Capping/crown corking
13. Storage

Fig 49: Chili Sauce

Machineries and Packaging Materials

Machineries

Washing tank
Blanching tank
Chilly pulping and straining machine
Steam jacketed kettle (for cooking)
Paste filling machine
Automatic pouch filling and sealing unit
Crown corking machine
Bottle sterilization system
Boiler (For steam generation)

Packaging Materials
Laminated PP/Glass bottles

Fig 50: Laminated PP

Fig 51: Chili Pulper

Fig 52: Steam Jacketed Kettle

Fig 53: Automatic Paste Filling Machine

Fig 54: Fill-Seal Machine for Chili Sauce

2.4.3.4. Green Chili Pickle

Raw Materials: Green chili: 1 kg ; salt: 150 g ; mustard ground: 100g ; lime juice: 200 ml or amchur: 200g ; fenugreek, aniseed, turmeric, cumin powder 15g each ; mustard oil: 400 ml.

Process Flow

1. Green chilly washing and removing stems
2. Making incision (longitudinal)
3. Mixing of dry salt or keeping inside 15 % brine solution for a week
4. Drying
5. Mixing all spices and oil (oil should be heated and cooled)
6. Packaging and storage

Fig 55: Green Chili Pickle

Machineries and Packaging Materials

Machineries

Washing tank
Blanching tank
Brine preparation tank
Tray dryer
Spice and oil blending arrangement
Automatic pouch filling and sealing machine
Aluminum foil sealer (on the round mouth plastic jars)

Packaging Materials

PP
Laminated PE
Glass jars/PET jars

Fig 56: Aluminum Foil Sealing Machine

Fig 57: Pickle Blending Machine

2.5. Bay Leaf

2.5.1. Introduction

Fig 58: Bay Leaf

Bay leaf (*Laurus nobilis*) is a thick, leathery, aromatic leaf with a bright green, glossy upper surface and a pale green colour beneath. The leaves are used as a condiment and spice but find major application in the pharmaceutical and ayurvedic medicine industry. In areas of the state conducive for its growth, it is common to find bay leaf trees thriving among other trees in a plantation that could have orange, areca nut or broom grass trees. It is a moderate sized evergreen tree with natural habitat mainly grown in the tropical and sub-tropical areas of Meghalaya. It has emerged as a semi-domesticated tree that provides supplementary income to marginal farmers. According to the International Forestry Research, Forest Livelihood 2008, the estimated

volume of production marketed annually from Meghalaya is 44370 MT valued at Rs. 576.8 million.

2.5.2. Processing of Dried Bay Leaf

Raw Materials: Green bay leaf

Process Flow

1. Cleaning
2. Grading
3. Shade drying/tray drying (Final moisture content 4-5 %)
4. Packaging & Storage

Machineries and Packaging Materials

Machineries

Washing tank
Tray dryer
Semiautomatic sealing machine

Packaging Materials

Fig 59: Laminated PP

Fig 60: Hand Operated Sealing Machine

Fig 61: Foot Operated Sealing Machine

2.6. Cinnamon

2.6.1. Introduction

Fig 62: Cinnamon

Cinnamon is a valuable spice that is obtained from the bark of an evergreen tree (*Cinnamomum zeylanicum*) that belongs to the Laurel family. Cinnamon is native to Sri Lanka, Myanmar (Burma) and the southern coastal strip of India. The crop now grows in South America and the West Indies, the Seychelles and Reunion. The best quality cinnamon is produced in Sri Lanka. Cassia, which is the bark of the evergreen tree *Cinnamomum cassia*, is a similar spice to cinnamon but of an inferior quality. It is a native of Myanmar (Burma). Most of the world's cassia comes from China, Indochina, Indonesia, the East and West Indies and Central America. Cassia bark is coarser and less fragrant than cinnamon and is sometimes used as a substitute. Cinnamon gets its distinctive smell and aroma from a volatile oil that is in the bark. The oil can be distilled from off-grade bark, leaves and roots.

Cinnamon bark is harvested twice a year immediately after each of the rainy seasons when the humidity makes the bark peel more easily. The trees are first harvested when they are three years old, one year after pruning. The side stems that are about three years old are removed and the bark is stripped off. Cinnamon bark is only obtained from stems that are between 1.2 and 5cm in diameter.

2.6.2. Processing of Dried and Powdered Cinnamon

Raw Materials: Green cinnamon bark

Process Flow

1. **Collection of Bark:** Remove the tender stems (with diameters less than 1.2cm) and use these for mulching.
   Stems with diameters of more than 5cm are not used to prepare cinnamon bark. Remove these and use for oil distillation.
   Remove the soft outer bark using a fine rounded rasp knife. Rub the stripped stem with a brass rod to loosen the inner bark. It is important to use a brass rod so that the bark does not become discoloured.
   Make cuts around the stem at 30cm intervals using a small pointed knife. The knife blade should be stainless steel or brass to prevent staining the bark.
   Make long cuts along the length of the stem, so that the bark can be carefully eased off the

stem. Use the pointed knife and the rubbing rod to help ease off the bark.
The pieces of removed bark are known as quills. Place these curled quills inside one another to make long compound quills (up to 1m long). Use the best whole quills on the outside and fill in the centre with broken pieces of bark.

2. **Drying:** The compound quills are placed on coir rope racks and dried in the shade to prevent warping. After four or five days of drying, the quills are rolled on a board to tighten the filling and then placed in subdued sunlight for further drying.
   In humid climates or during the rainy season it will be necessary to use a mechanical dryer to complete the drying process (at low temperature 50-55 ° C). There are a range of dryers available to suit different situations (electrical, gas fired, biomass fuelled). Moisture content of the dry cinnamon should be below 10 %.

Fig 63: Cinnamon Powder

3. **Grading:** The quality of cinnamon is judged by the thickness of the bark, the appearance (broken or entire quills) and the aroma and flavor.

4. **Grinding:** Grinding can be a method of adding value to a product. However, it is not advisable to grind spices. After grinding, spices are more vulnerable to spoilage. The flavour and aroma compounds are not stable and will quickly disappear from ground products. The storage life of ground spices is much less than for the whole spices. Cinnamon is sometimes ground to a powder prior to sale by mechanical grinder/pulverizer.

5. **Packaging:** Cinnamon quills are cut into pieces up to 10cm in length and packed into moisture-proof polypropylene bags for sale. The bags should be sealed to prevent moisture entering. Sealing machines can be used to seal the bags. Attractive labels should be applied to the products. The label needs to contain all relevant product and legal information – the name of the product, brand name (if appropriate), details of the manufacturer (name and address), date of manufacture, expiry date, weight of the contents, added ingredients (if relevant) plus any other information that the country of origin and of import may require (a barcode, producer code and packer code are all extra information that is required in some countries to help trace the product back to its origin).

Machineries and Packaging Materials

Machineries	**Packaging Materials**
Tray dryer	PP
Spice grinding/milling machine (same as turmeric)	Laminated PE
Sealing machine	(same as turmeric)

Fig 64: Spice Grinder

Fig 65: Form-Fill Sealing Machine

2.7. Rice

2.7.1. Introduction

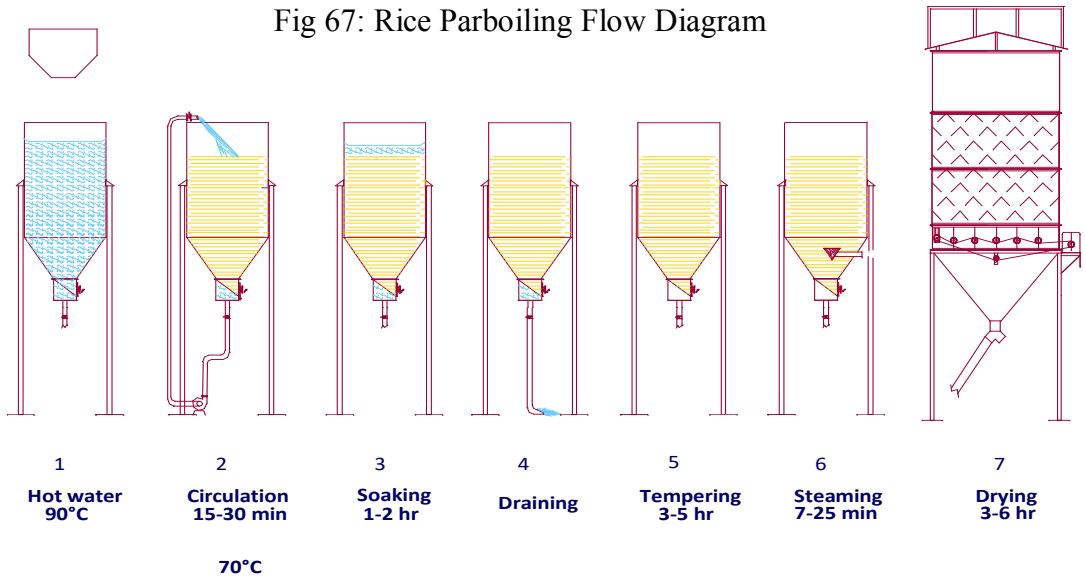
Rice (*Oryza sativa* L.) is second only to wheat as the leading food crop of the world. It is grown in over 100 countries and is staple food of half the world population. However, it is to be noted that more than 90 per cent of its production and consumption is concentrated in the South, East and South-East Asian countries. Rice is the major supplier of energy, protein and other nutrients in the diet of more than half of the Indian population. It is generally consumed as whole grain after boiling in water. It is generally estimated that about 10 percent of paddy produced in India is converted into three main whole grain products viz. expanded rice, popped rice and flaked rice which are popular in Indian sub-continent.

Fig 66: Rice

Rice is primarily a high energy calorie food. The major part of rice consists of carbohydrate in the form of starch, which is about 72-75 percent of the total grain composition. The protein content of rice is around 7 percent. The protein of rice contains glutelin, which is also known as oryzenin. The nutritive value of rice protein (biological value = 80) is much higher than that of wheat (biological value = 60) and maize (biological value = 50) or other cereals. Rice contains most of the minerals mainly located in the pericarp and germ and about 4 percent phosphorus. Rice also contains some enzymes.

A considerable quantity of rice is converted into many products and marketed in various rice consuming countries. These include breakfast cereals, quick cooking rice, instant rice, ready to eat cereals like oven puffed, gun puffed or extrusion puffed rice, shredded rice cereal, infant foods, fermented foods and various types of snack foods like rice cakes, granola, rice fries, pudding, krispies, cracker and noodles.

Fig 67: Rice Parboiling Flow Diagram



2.7.2. Rice Processing and Value Addition

2.7.2.1. Parboiled Rice

Raw Materials: Paddy

Process Flow

1. Paddy
2. Cleaning
3. Soaking (65- 70°C for 4 - 5 hr)
4. Steaming 10-30 min
5. Drying at 16-18% moisture content
6. Milling rice
7. Packaging
8. Labeling and storage.

Fig 68: Parboiled Rice

2.7.2.2. Flaked Rice

Raw Materials: Paddy

Process Flow

1. Paddy
2. Cleaning and soaking
3. RT to 70°C (approx. 30% moisture,)
4. Draining of water
5. Roasting (200-250°c for 20-30 sec)
6. Tempering
7. Flaking
8. Sieving flaked rice
9. Toasted flaked rice
10. Seasoning with fruit or spices
11. Packing
12. Store in cool and dry place

Fig 69: Flaked Rice

Machineries and Packaging Materials

Machineries

1. Paddy cleaning machine
2. Soaking Tank
3. Steaming Machine
4. Dryer
5. Paddy Dehusker
6. Aspirator & grader
7. Rubber polisher
8. Colour & Length Grader
9. Packaging machine
10. Uruli Roaster
11. Flaking machine
12. Aspirator & grader
13. Blending machine

Packaging Materials

PP/ Laminated PE, HDPE, Jute bag

Fig 70: HDPE Bag

Fig 71: Jute Bag

2.7.2.3. Puffed Rice

Raw Materials: Paddy

Process Flow

1. Paddy
2. Cleaning and soaking
3. Pressure Steaming
4. Drying 14% moisture content
5. Milling into parboiled rice
6. Salting (NaCl 10g/100ml water per kg of rice)
7. Dry heating (110°C)
8. Roasting in hot sand (250°C)
9. Puffed rice
10. Sieving
11. Cooling
12. Packing in airtight condition

Fig 72: Puffed Rice

2.7.2.4. Popped Rice

Raw Materials: Paddy

Process Flow

1. Paddy
2. Cleaning
3. Drying at 12-14% moisture content
4. Roasting in sand (150-200°C)
5. Popped rice
6. Sieving
7. Cooling
8. Packing in airtight condition
9. Storage

Fig 73: Popped Rice

Machineries and Packaging Materials

Machineries

1. Paddy cleaning machine
2. Soaking Tank
3. Steaming Machine
4. Dryer
5. Rice Milling machine

Packaging Materials

PP/ Laminated PE
HDPE
Jute bag

6. Puffing Machine
7. Aspirator & grader
8. Sifter
9. Colour & Length Grader
10. Packaging machine
11. Flaking machine
12. Aspirator & grader
13. Blending machine

2.7.2.5. Rice Papad

Raw Materials: 1 teaspoon ajwain; 1 teaspoon cumin seed; 4 teaspoons salt; 4-5 teaspoons green chili; 2 tablespoons sesame seeds; 3 teaspoons baking soda.; 4 cups rice flour.

Process Flow

1. Boil water and spices.
2. Addition of rice flour to the water and spice mixture.
3. Boiling and continuous stirring till the dough consistency comes
4. Separate the dough into pieces and make into flat balls
5. Steam the pieces for 10-15 min
6. Rolling into desired shape
   Drying

Fig 74: Rice Papad

Machineries and Packaging Materials

Machineries and other required setup	Packaging Materials
Dough mixing machine	PE/PP
Roller and cutter	
Dryer	

2.7.2.6. Rice Noodles

Raw Materials: Rice flour, water

Process Flow

1. Selection of fresh rice
2. Soaking in water (2-3 hrs) to reach moisture content about 25%
3. Dry grinding (MC- 25-26%) / Wet grinding (MC- 45-48%)
4. Rice slurry is then transported by a band career by sheets (5 mm thick)
5. Pre steaming of the sheets (4-5 min at 90° C)
6. Extrusion into noodles
7. Boiling (to ensure proper gelatinization)
8. Drying
9. Packaging

Fig 75: Rice Noodles

Machineries and Packaging Materials

Machineries	**Packaging Materials**
Dough mixing machine	
Sheeting machine	PE/PP Packet
Dryer	
Extruder/Noodle cutter	
Steaming and boiling machine	
Pouch sealing machine	

2.7.2.7. Rice Food Mix

Raw Materials: Rice-100g, Green gram-30g, Groundnut-20g, Sugar-50g.

Process Flow

1. Roast rice, mung dhal and groundnut separately
2. Grind rice, mung dhal and groundnut to a fine powder separately
3. Mix all the above. Add powdered sugar
4. Fill in dry containers and store

2.7.2.8. Puffed Rice Food Mix

Raw Materials: Puffed Rice-100g, Channa-30g, Groundnut-20g, Sugar-50g

Process Flow

1. Pick puffed rice and roast the Channa and groundnut separately
2. Grind rice, Channa and groundnut to a fine powder separately
3. Mix all the above. Add powdered sugar
4. Fill in dry containers and store

2.7.2.9. Flaked Rice Food Mix

Raw Materials: Flaked Rice-100g, Channa-30g, Groundnut-20g, Sugar-50g

Process Flow

1. Roast flaked rice, channa and groundnut separately
2. Grind flaked rice, channa and groundnut to a fine powder separately
3. Mix all the above and powdered sugar
4. Fill in dry containers and store

Fig 76: Mini Rice Mill

Fig 77: Rice Noodle machine

Fig 78: Roaster

Fig 79: Rice Flaking Machine

2.8. Maize

2.8.1. Introduction

Maize (Zea mays L) is the most widely distributed crops of the world. It is cultivated in the tropics, sub-tropics and temperate regions; from sea level to 4000 m above, under irrigated to semi-arid conditions. Globally, maize is known as "queen of cereals and a miracle crop because it has immense genetic yield potential among the cereals. Maize can be grown successfully in variety of soils ranging from loamy sand to clay loam. It can be produced in large volumes from small area, it is easy to grow and harvest. Maize is an important cereal in many developed and developing countries of the world. The United States of America (USA), the largest producer of maize contributes nearly 35 % of the total production in the world and maize is the driver of the US economy. The USA has the highest productivity (> 9.6 t ha^{-1}) which is double than the global average (4.92 t ha^{-1}).Whereas, the average productivity in India is 2.1 t ha^{-1}. India ranks sixth in global maize production, contributing to 2.4% of world production with almost 5% share in world harvested area. However, the country lags far behind in productivity – 24.7 quintal/ha against world average of 51.4 quintal/ha. The predominant maize growing states that contributes more than 80% of the total maize production are Andhra Pradesh (20.9 %), Karnataka (16.5 %), Rajasthan (9.9 %), Maharashtra (9.1 %), Bihar (8.9 %), Uttar Pradesh (6.1 %), Madhya Pradesh (5.7 %), Himachal Pradesh (4.4 %). Apart from these states maize is also grown in Jammu and Kashmir and North-Eastern states.

Fig 80: Maize

2.8.2. Nutritional Composition

Table 8: Maize kernel composition (%)

Kernel Faction	Protein	Oil	Starch	Sugars	Ash
Endosperm	9.4	0.8	86.4	0.64	0.31
Germ	18.8	34.5	8.2	10.81	10.10
Bran	3.7	1.0	7.3	0.34	0.84
Tipcap	9.1	3.8	5.3	1.61	1.59
Whole kernel	10.3	4.8	71.5	1.97	1.44

2.8.3. Processing and Value Addition of Maize

2.8.3.1. Corn Dry Milling

Corn dry milling system can be divided into two groups : the traditional non: degerming system and modern de-germing system. In the non de-germing system, the whole corn is ground into meal of high fibre as well as high protein contents by a stone grinder without removing germ. After grinding certain amount of germ and hull can be removed from the meal by sifting. In the de-germing system the corn is moistened with a little amount of water and tempered for moisture equilibration. After degerming the stock is dried, milled and classified into different products. The purpose of all dry de-germing corn milling methods is to remove hull, germ and. tip cap from the corn kernel as far as practicable andprimarily produce corn grits with some meals and flours. The germ is then used for oil extraction and deoiled germ, hull, etc., are used as feed which is known as hominy feed. The yield of endosperm products and hominy feed are about 70 per cent and 30 per cent respectively.

Tempering-Degerming (T.D.) Method of Dry Milling:

The major objectives of this method are to:

(a) Remove essentially all germ and hull so that endosperm contains as low fat and fiber as possible,
(b) Recover a maximum amount of the endosperm as large clean grits without any dark speck, and
(c) Recover a maximum amount of germ as large and pure particles.

Basic Processes

Cleaning of corn

Thorough cleaning of corn is essential for the subsequent milling operations. Pieces of iron, etc., are removed by magnetic separators. Dry cleaners consisting of sieves and aspirators and sometimes a wet cleaner consisting of a washing de-stoning unit and a mechanical type dewatering unit, known as whizzer, are used for cleaning of corn.

Hydrothermal treatment / conditioning

Predetermined amount of moisture is added to the corn in the form of cold or hot water or steam in on6, two or three stages with appropriate tempering times after each stage. The tempering times (rest periods) vary according to the hydration methods. So, also tempering temperatures vary from room temperature to about 50^{o}C accordingly. The optimum moisture content for degerming in the Beall Degermer is 2l-25 per cent. Either cold or hot water is used for the addition of moisture. A little heat in the form of open steam is added as and when necessary.

Degerming

The purpose of degerming is to remove hull, tip cap, and germ as far as practicable and leave the endosperm into large grits. However, the products from degermer consists of a mixture of kernel components, freed from each other to varying degrees, with the endosperm particles varying in sizes from grits to flour. The Beall Degermer consists of a rotating cast iron conical roller mounted on a horizontal shaft in a conical cage. Part of the cage is fitted with perforated screens and the remainder with plates having conical projections on its inner surface. The rotating cone has similar projections over most of its surface. The feed end of the cone has spiral corrugations to move the corn forward whereas the large end has corrugations in an opposite direction to retard the flow. The product leaves the unit in two streams. The major portions of the released germ, husk and fines as well as some of the grits are discharged through the perforated screens.

Drying and cooling of degermer stock

The degermer products are to be dried to 15 to 18 per cent moisture content for proper grinding and sifting. Generally rotary steam tube dryers are used for drying the product. Rotary Louver type dryer can also be employed. The stock is heated to about 50^{o}C. Counter flow or cross-flow rotary, vertical gravity or fluidized bed types of cooler can be used for cooling the dried products.

Rolling and Grading

Recovery of various primary products is the next step. Further release of germ and husk from the endosperm products occurs during their gradual size reduction roller mills. The germ, husk and endosperm fragments are then separated by means of sifters, aspirators, specific gravity table separators or purifiers. Sifting is an important operation and is variously referred to as scalping, grading, classifying, or bolting depending upon the means used and purpose. Sifting is actually a size separation operation on sieves. Scalping is the coarse separation made on the product leaving a roller mill or degermer. Grading or classifying is the separation of a single stock (usually endosperm particles) into two or more groups according to particle size. Bolting is the removal of hull fragments from a corn meal or flour.

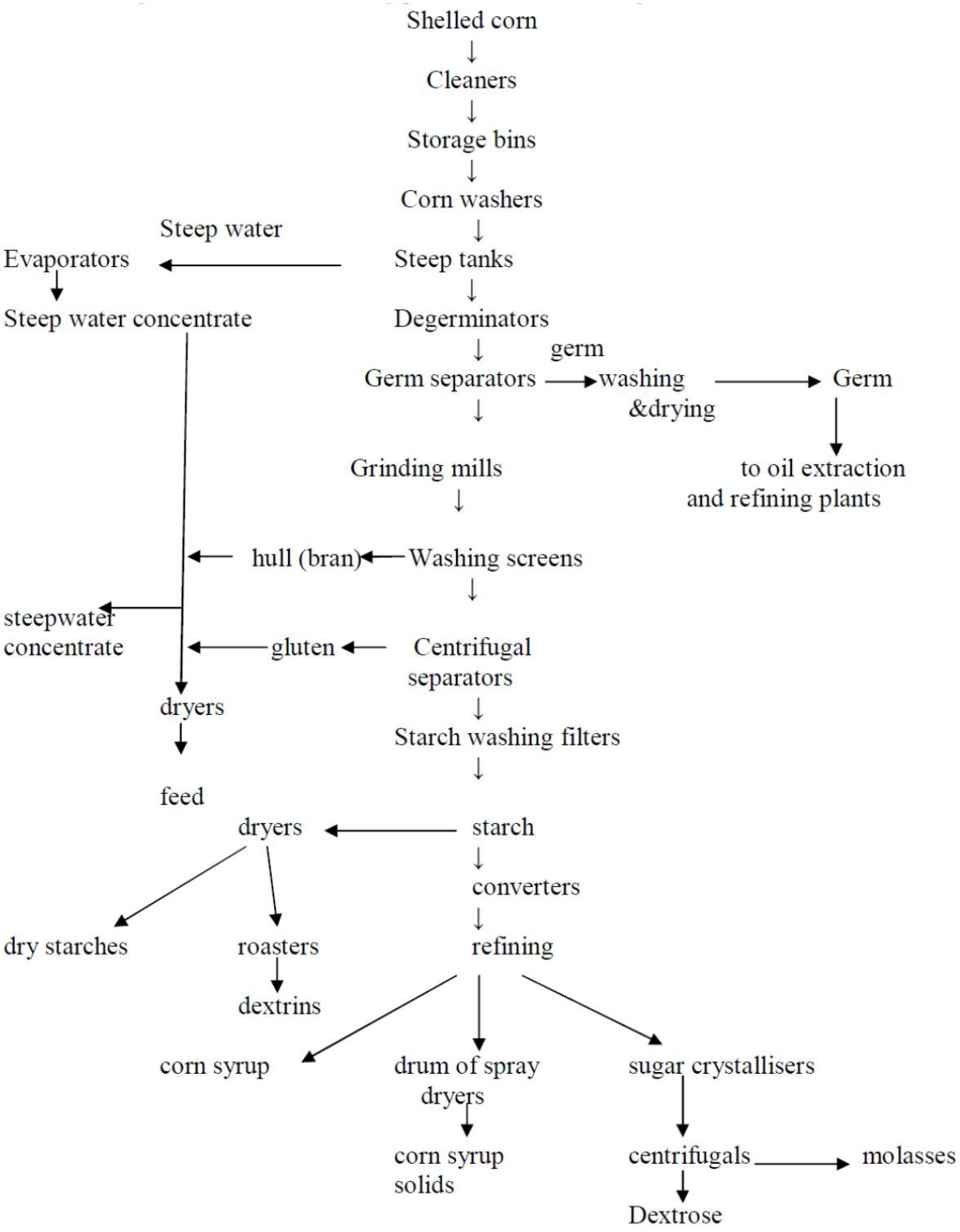
Further drying of the products is done as and when necessary.

Blending and packaging of products.

2.8.3.2. Corn Wet Milling

The raw corn for wet milling should contain 15-16 per cent moisture and it should be physically sound. Insect and pest infested, cracked and heat damaged corns (treated at temperature around 75^{o}C during drying) are unsuitable for wet milling. The wet milling process consists of (a) Cleaning, (b) Soaking, (c) Germ separation and recovery, (d) Grinding and hull recovery, and (e) Separation of starch and gluten.

Fig 81: Process of Wet Milling



2.8.3.3. Corn Flakes

Raw Materials: Corn flour, rice flour/ other cereal flour, sugar/honey, flavor.

Process Flow

1. Corn flour premixing (mixed with other cereal flours)
2. Extrusion
3. Flaking
4. Drying
5. Baking
6. Enrobing (using, sugar/ honey/ other flavoring substances)
7. Drying
8. Packaging

Fig 82: Corn Flakes

Corn Flakes Processing Line

Fig 83: Corn Flakes Processing Line

Machineries and Packaging Materials

Machineries	Packaging Materials
Mixer	
Double screw extruder	Laminated PE/ Aluminum foil (Primary)
Flaking machine	Paperboard (secondary)
Vibratory cooler	
Dryer	
Baking machine	
Sugar coating machine	
Automatic pouch sealing machine	

2.9. Vegetables (Carrot, Beans, Cauliflower, Squash, Potato, and Tomato)

2.9.1. Drying and Dehydration of Vegetables

Drying is one of the oldest methods of preserving food. Removes moisture stops the growth of bacteria, yeasts & molds that normally spoil food. It slows down but doesn't completely inactivate enzymes. When drying foods, the key is to remove moisture as quickly as possible at a temperature that does not seriously affect the flavor, texture and color of the food. If the temperature is too low in the beginning, microorganisms may survive and even grow before the food is adequately dried. If the temperature is too high and the humidity too low, the food may harden on the surface. This makes it more difficult for moisture to escape and the food does not dry properly. Although drying is a relatively simple method of food preservation, the procedure is not exact. A "trial and error" approach often is needed to decide which techniques work best.

Nutritional Value of Dried Foods

Drying, like all methods of preservation, can result in loss of some nutrients. Nutritional changes that occur during drying include:

Calorie content: does not change, but is concentrated into a smaller mass as moisture is removed.
Fiber: no change.
Vitamin A: fairly well retained under controlled heat methods.
Vitamin C: mostly destroyed during blanching and drying of vegetables. Thiamin, riboflavin, niacin: some loss during blanching but fairly good retention if the water used to rehydrate also is consumed.
Minerals: some may be lost during rehydration if soaking water is not used. Iron is not destroyed by drying. For best retention of nutrients in dried foods store in a cool, dark, dry place and use within a year.

Drying Techniques

Various drying techniques are now a day applied for various commodities according to their composition and final product quality. Some popular drying techniques are as follows:

- Sun or solar drying (fruits, vegetables, cereal and pulses, spices)
- Freeze drying (low temperature drying to dry fruits and vegetables to retain maximum of its quality)
- Drum drying (drying of paste/ slurry products)
- Spray drying (liquid product drying as: milk, juice etc.)
- Vacuum drying (low temperature drying to dry fruits and vegetables to retain maximum of its quality)
- Convection air & Superheated steam (tray, tunnel type for fruits, vegetable and spices)
- Osmotic drying (Using concentrated sugar syrup or salt. Applied mainly for fruits)
- Microwave

Process Flow

1. Selection of vegetables
2. Grading, washing, and peeling
3. Slicing/dicing/chopping (according to the demand)
4. Blanching (to remove dirt, lower the surface microbial load, and to inactivate enzymes which effects the appearance)
5. Drying and cooling
6. Packaging and storage

Fig 84: Dried Vegetables

Drying Treatments for Selected Vegetables

Table 9: Standard blanching and drying Parameters of some vegetables

Vegetables	Blanching condition	Drying condition
Carrot (10 mm thick slices)	2-4 min in 2 % salt solution	55- 60 °C (final M.C- ≤10 %)
Cauliflower (break flower into small pieces)	4-5 min in boiling water and 1 hr in 0.1% KMS solution	55- 60 °C (final M.C- ≤10 %)
Potato (10 mm thick slices)	4-5 min in boiling water or steam and 15- 20 min in 0.1 % KMS solution	60°C (final M.C- ≤10 %)
Beans (5-6 mm thick slices)	4- 5 min in boiling water	55- 60 °C (final M.C- ≤10 %)
Squash (10 mm thick slices)	4-5 min in boiling water and 1 hr in 0.1% KMS solution	55- 60 °C (final M.C- ≤10 %)

Machineries and Packaging Materials

Machineries	Packaging Materials
Vegetable washer/ tank	
Vegetable slicer, dicer, chopper	Laminated PE/PP
Blanching machine	Plain PP
Electric tray dryer	
Semi automatic pouch sealing machine	
Vacuum packaging machine	

2.9.2. Freezing of Vegetables

Freezing has been successfully employed for the long-term preservation of many foods, providing a significantly extended shelf life. The process involves lowering the product temperature generally to -18 °C or below (Fennema et al., 1973). The physical state of food material is changed when energy is removed by cooling below freezing temperature. The extreme cold simply retards the growth of microorganisms and slows down the chemical changes that affect quality or cause food to spoil (George, 1993).Competing with new technologies of minimal processing of foods, industrial freezing is the most satisfactory method for preserving quality during long storage periods (Arthey, 1993). When compared in terms of energy use, cost, and product quality, freezing requires the shortest processing time. Any other conventional method of preservation focused on fruits and vegetables, including dehydration and canning, requires less energy when compared with energy consumption in the freezing process and storage. However, when the overall cost is estimated, freezing costs can be kept as low (or lower) as any other method of food preservation (Harris and Kramer, 1975).

Slow Freezing

- Rates of cooling of less than 1°C/min
- Ice crystals form in extracellular locations
- Large ice crystals formation
- Maximum dislocation of water
- Shrinkage (shrunk appearance of cells in frozen state)
- Less than maximum attainable food quality

Rapid Freezing

- Produces both extracellular and intracellular (mostly) locations of ice crystals
- Small and Numerous ice crystals
- Minimum dislocation of ice crystals

- Frozen appearance similar to the unfrozen state
- Food quality usually superior to that attained by slow freezing

Freezing Types (Equipment):

Mechanical

- Direct
- Indirect (ammonia, others)

Cryogenic

- CO_2
- N_2

Slow freezers and sharp freezers (0.2 cm/h): Still-air freezers and cold stores

Quick freezers (0.5-3 cm/h): Air-blast and plate freezers

Rapid freezers (5-10 cm/h): Fluidized-bed freezers

Ultra-rapid freezers (10-100 cm/h): Cryogenic freezers.

Air-blast Freezers

The air blast freezer is one the oldest and commonly used freezing equipment due to its temperature stability and versatility for several product types. In general, air is used as the freezing medium in the freezing design, either as still air or forced air. Freezing is accomplished by placing the food in freezing rooms called sharp freezers. Still, air freezing is the cheapest way of freezing and has the added advantage of a constant temperature during frozen storage, which allows usage for unprocessed bulk products like beef quarters and fish. However, it is the slowest method of freezing due to the low surface heat transfer coefficient of circulating air inside the room. Freezing time in sharp freezers is largely dependent on the temperature of the freezing chamber and the type, initial temperature, and size of product (Desrosier and Desrosier 1977). An improved version of the still air freezer is the forced air freezer, which consists of air circulation by convection inside the freezing room. However, even modification of the sharp freezer with extra refrigeration capacity and fans for increased air circulation does not help control the air flow over the products during slow freezing. There are a considerable number of designs and arrangements for air blast freezers, primarily grouped in two categories depending on the mode of process, as either inline or batch. Continuous freezers are the most suitable systems for mass production of packaged products with similar freezing times, in which the product is carried through on trucks or on conveyors. The system works on a semi-batch principle when trucks are used, since they remain stationary during the process except when a new truck enters one end of the tunnel, thus moving the others along to release a finished one at

the exit. The batch freezers are more flexible since a variety of products can be frozen at the same time on individual trolleys. Over-loading may be a problem for these types of freezers, thus the process requires closer supervision than continuous systems.

Tunnel Freezers

In tunnel freezers, the products on trays are placed in racks or trolleys and frozen with cold air circulation inside the tunnel. In order to allow air circulation, optimum space is provided between layers of trolley, which can be moved continuously in and out of the freezer manually or by forklift trucks. This freezing system is suitable for all types of products, although there are some mechanical constraints including the requirement of high manpower for handling, cleaning, and transportation of trays (Mallett, 1993).

Belt Freezers

Belt freezers were first designed to provide continuous product flow with the help of a wire mesh conveyor inside the blast rooms. A poor heat transfer mechanism and the mechanical problems were solved in modern belt freezers by providing a vertical airflow to force air through the product layer. Airflow has good contact with the product only when the entire product is evenly distributed over the conveyor belt. In order to decrease required floor space, the belts can be arranged in a multi-tier belt freezer or a spiral belt freezer. Spiral belt freezers consist of a belt that can be bent laterally around a rotating drum to maximize belt surface area in a given floor space. This type of design has the advantage of eliminating product damage in transfer points, especially for products that require gentle handling (Mallett, 1993). Both packed and unpacked products with long freezing times (10 min to 3 hr) can be frozen in spiral belt freezers due to the flexibility of the equipment (ASHRAE, 1994).

Fluidized Bed Freezers

The fluidized bed freezer, a fairly recent modified type of air-blast freezer for particular product types, consists of a bed with a perforated bottom through which cold air is blown vertically upwards (Rahman, 1999). The system relies on forced cold air from beneath the conveyor belt, causing the products to suspend or float in the cold air stream (George, 1993). The use of high air velocity is very effective for freezing unpacked foods, especially when they can be completely surrounded by flowing air, as in the case of fluidized bed freezers.

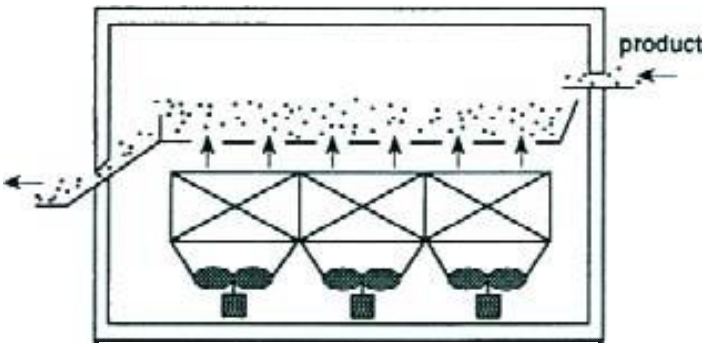
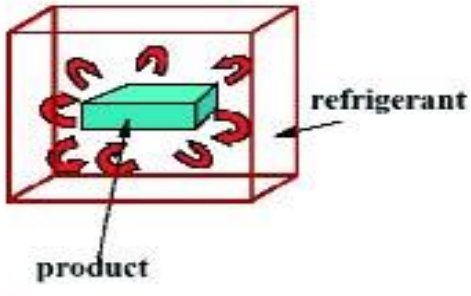


Fig 85: Fluidized Bed Freezer

Contact Freezers

Contact freezing is the one of the most efficient ways of freezing in terms of heat transfer mechanism. In the process of freezing, the product can be in direct or indirect contact with the freezing medium. For direct contact freezers, the product being frozen is fully surrounded by the freezing medium, the refrigerant, maximizing the heat transfer efficiency. For indirect contact freezers, the product is indirectly exposed to the freezing medium while in contact with the belt or plate, which is in contact with the freezing medium (Mallett, 1993).

Fig 86: Contact Freezer

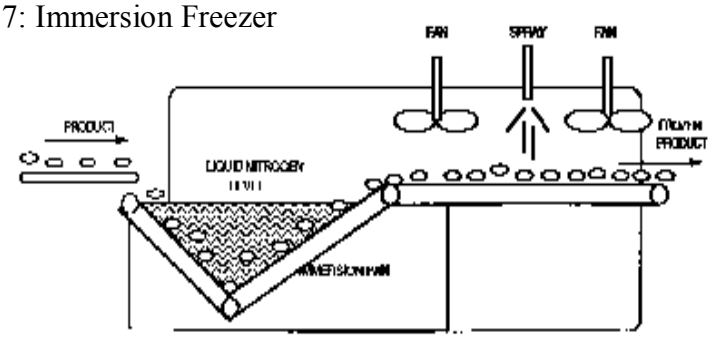


Immersion Freezers

The immersion freezer consists of a tank with a cooled freezing media, such as glycol, glycerol, sodium chloride, calcium chloride, and mixtures of salt and sugar. The product is immersed in this solution or sprayed while being conveyed through the freezer, resulting in fast temperature reduction through direct heat exchange (Hung and Kim, 1996). Direct immersion of a product into a liquid refrigerant is the most rapid way of freezing since liquids have better heat conducting properties than air. The solute used in the freezing system should be safe without taste, odour, colour, or flavour, and for successful freezing, products should be greater in density than the solution. Immersion freezing systems have been commonly used for shell freezing of large particles due to the reducing ability of product dehydration when the outer layer is frozen quickly. A commonly seen problem in these freezing systems is the dilution of solution with the

product, which can change the concentration and process parameters. Thus, in order to avoid product contact with the liquid refrigerant, flexible membranes can be used (George, 1993).

Fig 87: Immersion Freezer



Indirect Contact Freezers

In this type of freezer, materials being frozen are separated from the refrigerant by a conducting material, usually a steel plate. Indirect contact freezers generally provide an efficient medium for heat transfer, although the system has some limitations, especially when used for packaged foods due to resistance of package to heat transfer. Additionally, corrosive effects may occur due to interaction of metal packages with heat transfer surfaces.

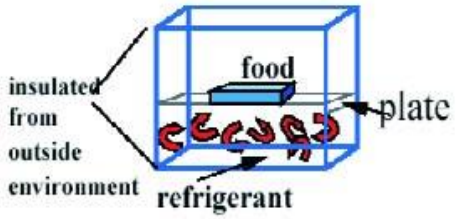


Fig 88: Indirect Contact Freezer

Plate Freezers

The most common type of contact freezer is the plate freezer. In this case, the product is pressed between hallow metal plates, either horizontally or vertically, with a refrigerant circulating inside the plates.

Fig 89: Plate Freezer

Contact Belt Freezers

This type of freezer is designed with single-band or double-band for freezing of thin product layers. The design can be either straight forward or drum. Typical products frozen in belt freezers are, fruit pulps, egg yolk, sauces and soups (Persson and Lohndall, 1993).

Cryogenic Freezers

Cryogenic freezing is a relatively new method of freezing in which the food is exposed to an atmosphere below -60 °C through direct contact with liquefied gases such as nitrogen or carbon dioxide (Hung and Kim, 1996). This type of system differs from other freezing systems since it is not connected to a refrigeration plant; the refrigerants used are liquefied in large industrial installations and shipped to the food-freezing factory in pressure vessels. Thus, the small size and mobility of cryogenic freezers allow for flexibility in design and efficiency of the freezing application. Low initial investment and rather high operating costs are typical for cryogenic freezers (Persson and Lohndal, 1993).

Liquid Nitrogen Freezers

Liquid nitrogen, with a boiling temperature of -196 °C at atmospheric pressure, is a by-product of oxygen manufacture. The refrigerant is sprayed into the freezer and evaporates both on leaving the spray nozzles and on contact with the products. The system is designed in a way that the refrigerant passes in counter current to the movement of the products on the belt giving high transfer efficiency. The refrigerant consumption is in the range of 1.2-kg refrigerant per kg of the product. Typical food products used in this system are, fish fillets, seafood, fruits, berries (Persson and Lohndal, 1993).

Liquid Carbon-dioxide Freezers

Liquid carbon dioxide exists as either a solid or gas when stored at atmospheric pressure. When the gas is released to the atmosphere at -70 °C, half of the gas becomes dry-ice snow and the other half stays in the form of vapor. This unusual property of liquid carbon dioxide is used in a variety of freezing systems, one of which is a pre-freezing treatment before the product is exposed to nitrogen spray (George, 1993).

2.9.2.1. Freezing of Beans

Raw Materials: Fresh mature beans

Process Flow

1. Beans (mature)
2. Removal of strings (fibre)
3. Cutting into 2 cm pieces
   Blanching for 5 min (direct immersion in boiling water)
4. Cooling in water
5. Packing in PE bag
6. Sealing
7. Arranging in cartoons
8. Freezing by plate freezer
9. Storage (- 18 ° C)

Fig 90: Frozen Bean in Laminated PP Packet

2.9.2.2. Freezing of Carrot

Raw Materials: Fresh mature carrot

Process Flow

1. Carrot
2. Washing
3. Peeling of skin
4. Cutting into 2 cm pieces
5. Blanching for 3 min (in boiling water)
6. Cooling
7. Sealing in PE bags
8. Arranging in cartons
9. Freezing (at -1 to -5° C)
10. Storage (- 18 ° C)

Fig 91: Frozen Carrot in Laminated PP Packet

2.9.2.3. Freezing of Cauliflower

Raw Materials: Fresh mature cauliflower

Process Flow

1. Cauliflower (Mature)
2. Cutting into bits
3. Blanching for 2 min (in boiling water)
4. Cooling
5. Dipping in 0.05 % KMS solution for 5 min (ratio of material to solution 1:4)
6. Draining
7. Packaging in PE bags

8. Sealing
9. Arranging in cartons
10. Freezing (at -1 to -5° C)
11. Storage (- 18 ° C)

Machineries and Packaging Materials

Machineries
Vegetable washer/ tank
Vegetable slicer, dicer, chopper
Blanching machine
Deep freezer (-18° C)
Semi automatic pouch sealing machine
Vacuum packaging machine

Packaging Materials

Laminated PE/PP
Plain PP

Fig 92: Veg. blanching and washing machine

Fig 93: Veg. Slicer, Dicer, Shredder

Fig 94: Veg. Tray dryer

Fig 95: Vacuum packaging machine

Fig 96: Deep Freezer

Fig 97: Sealing machine for dry veg. PP packet

2.9.3. Spiced Carrot Juice

Raw Materials: Grated carrot: 1 kg; common salt: 32 g; mustard powder: 3 g; vinegar: 62g; red chili powder: 1.5 g, Sodium benzoate: 350 ppm

Process Flow

1. Selection of deep orange variety of carrots
2. Washing
3. Removal of hairy parts
4. Chopping of two ends
5. Grating
6. Incubating with enzyme (210.7 mg mixture of pectolytic and cellulolytic enzyme/kg blanched carrots at 47°C adjusting pH ranging 4.5-4.7)
7. Straining
8. Clear juice
9. Addition of other ingredients and acidification
10. Pasteurization (90°C for 1 min)
11. Cooling and addition of preservative (SB- 350 ppm)
12. Packaging. Dilute the beverage 2-3 times with water before use

Fig 98: Carrot Juice

Machineries and Packaging Materials

Machineries	**Packaging Materials**
Washer	
Grater	Glass bottles
Enzyme incubation tank	PET bottles
Juice pressing equipment	
strainer	

Blending tank
Pasteurizer
Automatic bottling unit
Capping and labeling unit
Cold store

Fig 99: Carrot Juice Pasteurizer

Fig 100: Filling/Bottling Unit for Juice

2.9.4. Vegetables Preservation in Brine Solution

Raw Materials: Carrot, beans, cauliflower, squash, salt, vinegar

Process Flow

1. Selection of vegetables
2. Grading, washing, and peeling
3. Slicing/dicing/chopping (according to the demand)
4. Blanching (in hot water for 4-5 min)
5. Preparation of brine (12-15 % salt in vinegar solution or in water)
6. Putting the vegetables in brine solution
7. Capping and storage

Fig 101: Veg. preservation in brine

Machineries and Packaging Materials

Machineries	**Packaging Materials**
Vegetable washer/ tank	
Vegetable slicer, dicer, chopper	Glass jars
Blanching machine	SS drums
Brine preparation tank (SS)	

2.9.5. Mixed Vegetables Pickle

Pickle is one of the most ancient methods of preserving fruits and vegetables. Pickles are good appetizers and add to the palatability of a meal. They stimulate the flow of gastric juice and thus help in digestion. Pickling is the process by which fresh fruits and vegetables are preserved and with the addition of salt, chilly and spices, a tasty preparation known as "Pickles" is made.

Principle of Pickling

Pickling is the result of fermentation by lactic acid-forming bacteria present in large numbers on the surface of fresh vegetables and fruits. These bacteria can grow in acid medium and in the presence of 8-10 per cent salt solution, whereas the growth of a majority of undesirable organisms is inhibited. Lactic acid bacteria are most active at 30°C, so this temperature must be maintained as far as possible in the early stage of pickle making. When vegetables are placed in brine, it penetrates into the tissues of the former and soluble material present in them diffuses into the brine by osmosis. The soluble material includes fermentable sugars and minerals. The sugars serve as food for lactic acid bacteria which convert them into lactic and other acids. The acid brine thus formed acts upon vegetable' tissues to produce the characteristic taste and aroma of pickle. In the dry salting method several alternate layers of vegetables and salt (20- 30 g of dry salt per kg vegetables) are kept in a vessel which is covered with a cloth and a wooden board and allowed to stand for about 24 hours. During this period, due to osmosis, sufficient juice comes out from the vegetables to form brine. Vegetables which do not contain enough juice (e.g. cucumber) to dissolve the added salt are covered with brine (steeping in a concentrated salt solution is known as brining). The amount of brine required is usually equal to half the volume of vegetables. Brining is the most important step in pickling. The growth of a majority of spoilage organisms is inhibited by brine containing 15 per cent salt. Lactic acid bacteria, which are salt-tolerant, can thrive in brine of 8-10 per cent strength though fermentation takes place fairly well even in 5 per cent brine. In brine containing 10 per cent salt fermentation proceeds somewhat slowly. Fermentation takes place to some extent up to 15 per cent but stops at 20 per cent strength. It is, therefore, advisable to place the vegetables in 10 per cent salt solution for vigorous lactic acid fermentation.

As soon as the brine is formed, the fermentation process starts and carbon dioxide begins to evolve. The salt content is now increased gradually, so that by the time the pickle is ready, salt concentration reaches 15 per cent. When fermentation is over, gas formation ceases. Under favorable conditions fermentation is completed in 7 to 10 days. When sufficient lactic add has been formed, lactic acid bacteria cease to grow and no further change takes place in the vegetables. However, precautions should be taken against spoilage by aerobic microorganisms in the presence of air pickle scum is formed which brings about putrefaction and destroys the lactic acid. Properly brined vegetables keep well in vinegar for a long time.

FPO Speciation of Pickles

1. Any edible vegetable oil like rape seed, mustard, olive oil can be used.
2. Any suitable variety fruit can be used
3. The fruits used in the preservation, shall be wholesome. Add only spices, salt, oil, sugar, jiggery, condiments and preservatives.
4. The permissible limit of preservative as sulphur dioxide 100 ppm and benzoic acid 250ppm.In case salt pickle minimum percentage of salt should be 12 and all ingredients used shall be thoroughly mixed clean and free from extraneous matter.

Raw Materials: Vegetables (cauliflower, carrot, beans, squash): 1 kg; Salt: 100 g; Ginger: 20g; Onion: 50g; Garlic: 10g; Red chilly,, black pepper, turmeric, cardamom, aniseed, cumin, fenugreek (powdered): each 10g; Cloves(head less): 5 nos; Mustard (ground): 50g; Vinegar: 200 ml/ acetic acid: 40 ml; Mustard oil: 450 ml

Pickling Process Flow

1. Vegetables washing, peeling, slicing/dicing
2. Blanching in hot water
3. Mixing of dry salt or keeping inside 15 % brine solution for a week
4. Drying
5. Mixing all spices and oil (oil should be heated and cooled)
6. Packaging and storage

Fig 102: Mixed veg. pickle

2.9.6. Vegetables Canning

The process of sealing foodstuffs hermetically in containers and sterilizing them by heat for long storage is known as canning. In 1804, Appert in Frarice invented a process of sealing foods hermetically in containers and sterilizing them by heat. Appert is known as the 'Father of Canning'. This work formed the foundation for modern canning procedure. In honor of the inventor, canning is also known as appertizing. Saddington in England was the first to describe a method of canning of foods in 1807. In 1810, Peter Durand, another Englishman, obtained the first British Patent on canning of foods in tin containers. In 1817, William Underwood introduced canning of fruits on a commercial scale in U.S.A. Fruits and vegetables are canned in the season when the raw material is available in plenty. The canned products are sold in the off-season and give better returns to the grower.

Raw Materials: Vegetable pieces, salt

Process Flow

1. Selection of vegetables
2. Grading, washing, and peeling
3. Slicing/dicing/chopping (according to the demand)
4. Blanching (in hot water for 4-5 min)
5. Filling in can and brining (2 % salt solution may be used)
6. Exhausting
7. Sealing
8. Sterilization
9. Cooling
10. Storage

Fig 103: Canned vegetables

FPO Specification for Canned Vegetables

1. Head space in the can shall not be more than 1.6 cm
2. The drained weight shall not be less than 50% for fruits and 55 % for vegetables (except tomato) and the fruit should be firm.
3. No preservative shall be added. No artificial colour should be present
4. The can shall not show any positive pressure at sea level and shall not show any sign of bacterial growth when incubated at 37°C for a week

Containers for Packing of Canned Products

Both tin and glass containers are used in the canning industry, but tin containers are preferred.

Tin Containers

Tin cans are made of thin steel plate of low carbon content, lightly coated on both sides with tin metal. It is difficult to coat the steel plate uniformly and during the process of manufacture small microscopic spots are always left uncoated, although the coating may appear perfect to the eye. The contents of the can may react with these uncoated spots resulting in discoloration of the product or corrosion of the tin plate. When the corrosion is severe, black stains of iron sulphide are produced. It is necessary, therefore, to coat the inside of the can with some material (lacquer) which prevents discolouration but does not affect the flavour or wholesomeness of the contents. This process is known as "Lacquering".

Two types of Lacquers

Acid Resistant: Acid-resistant lacquer is golden coloured enamel and cans coat with it are called R-enamel or A.R cans. These cans are used for packing acid fruits which are of two kinds: (a) those whose colouring matter is insoluble in water, e.g., peach, pineapple, apricot, grapefruit, and

(b) those in which it is water-soluble, e.g., raspberry, strawberry, red plum and coloured grape. Fruits of group (a) are packed in plain cans and those of group (b) in lacquered cans.

Sulphur Resistant: This lacquer is also of a golden colour and cans coat with it are called C-enamel or S.R. cans. They are meant for non-acid foods only and should not be used for any highly acid product as acid eats into the lacquer. These cans are used for pea, corn, lima bean, red kidney bean, etc.

Spoilage of Can Products, Indication and Prevention

Table 10: Nature of spoilage , indication and prevention technique for can products

Problems	Indication	Prevention
Hydrogen swell	Bulging is due to the hydrogen gas produced by the action of food acids on the metal of the can.	Using good quality of tin plate, addition citric acid to syrup, proper exhausting, firm placing of lid, proper head space (0.6cm to 0.9cm) and store in cool and dry condition.
Leaker	Leakage due to defective or faulty seaming, corrosion both inside & outer side of the can physical damage during handling .	Precautions should be taken to avoid these problems.
Discoloration of products (Black, brown and pink)	Due biological reaction such as enzymatic and non enzymatic browning or metallic contamination.	Enzymatic browning can be preventing by regulation of exhausting process and blanching. Metallic contamination can be avoided by eliminating the use of iron and copper vessels and using lacquered can, glass container, ss equipments.
Flat souring	Cause by thermophilic bacteria.	It can be minimized by cleaning, washing the materials prior to canning and proper exhausting and processing.
Formation of acid and gasses	Caused by the thermophilic anaerobic bactetia The thermophilic anaerobic bactetia produces carbon dioxide and hydrogen gasses which develop pressure and cause bulging.	This can be prevented by appropriate processing and cooling the can about 37°C.

Sulphide spoilage	Sulphur dioxide is produces by bactertia which reacts with can and cause darkening and browning of the products. This problems occurs in acid /low acid fruits/vegetables.	This can be prevented by appropriate processing or avoid under processing.

Machineries and Packaging Materials

Machineries	**Packaging Materials**
Fruits & Vegetables Grader	
Fruits & Vegetables Washing Machine	Tin can
Cutting & Peeling machine	
Blancher	
Can reformer	
Can Flanger	
Can Double seamer	
Filling Machine	
Exhaust Box	
Sterilizer	
Cooling Tank	
Baby Boiler	

Fig 104: Can Reformer

Fig 105: Can Flanger

Fig 106: Can Double Seamer

Fig 107: Can Exhaust

Fig 108: can retort

Fig 109: Can

2.10. Tomato

2.10.1. Introduction

Fig 110: Tomato

Tomato (*Lycopersicon esculentum*) belongs to the genus Lycopersicon under Solanaceae family. Tomato is a herbaceous sprawling plant growing to 1-3 m in height with weak woody stem. The flowers are yellow in colour and the fruits of cultivated varieties vary in size from cherry tomatoes, about 1–2 cm in size to beefsteak tomatoes, about 10 cm or more in diameter. Most cultivars produce red fruits when ripe. Tomato is a native to Peruvian and Mexican region. Though there are no definite records of when and how it came to India , the Portuguese perhaps introduced it to India. Tomato is one of the most important "protective foods" because of its special nutritive value. It is one of the most versatile vegetable with wide usage in Indian culinary tradition. Tomatoes are used for soup, salad, pickles, ketchup, puree, sauces and in many other ways It is also used as a salad vegetable. Tomato has very few competitors in the value addition chain of processing. Tomato, though botanically a fruit for the purpose of trade, is generally considered a vegetable because of the way in which it is consumed. Tomatoes are widely grown in all parts of the world. Tomatoes are produced and processed during the two main seasons across much of India – August to October (kharif) and December to April (rabi). Where conditions suit, tomatoes are also grown during the off-season (May to July) including under protected cultivation though given the low volumes of production, prices are often the highest during this period.

2.10.2. Processing and Value Addition of Tomato

2.10.2.1. Tomato Juice

Raw Materials: Tomato pulp: 1 kg; Sugar: 10g; Salt: 5g; Citric acid: 1g; Sodium benzoate: 1g.

Process Flow

1. Tomatoes (fully ripe, deep red color)
2. Washing
3. Cutting/chopping (4-6 pieces)
4. Heating at 90°C for 15 min (to soften)
5. Pulping/extraction of juice
6. Addition of other ingredients
7. Homogenization
8. Heating at 82-88°C for 1 min
9. Filling hot into bottles/cans
10. Sterilization in boiling water for 30 min

Fig 111: Tomato Juice in PET Bottles

11. Cooling

FPO Specification: Min TSS 5%, Salt 0.5%, Sugar 1%, Acid 0.4%

2.10.2.2. Tomato Puree and Paste

Raw Materials: Fully ripe, red colored tomato

Process Flow

1. Extraction of tomato juice/pulp (Follow the previous method)
2. Cooking to desired consistency (Open cooker/vacuum pan)
3. Judging the end point (using hand refractometer. Puree (9-12%), Paste: 25%)
4. Filling in sterilized cans or bottles
5. Filling in sterilized cans or bottles
   Sterilization of bottles in boiling water (20-30 min)
6. Cooling
7. Storage

Fig 112: Tomato Puree

FPO Specification: Min TSS for medium puree 9%, heavy puree 12% and paste 25%, Sodium benzoate maximum 250 ppm.

2.10.2.3. Tomato Sauce/ Ketchup

Raw Materials: Tomato pulp: 1kg; Sugar: 75g; Salt: 10g; Onion: 50g; Ginger: 10g; Garlic: 5g; Red chilli powder: 5g; Cinnamon, cardamom, aniseed, cumin, black pepper (powdered): 10g each; Clove (head less): 5 nos; Vinegar: 25 ml/acetic acid: 5 ml; Sodium benzoate: 0.75g per kg of final product.

Process Flow

1. Tomatoes (fully ripe, deep red color)
2. Washing
3. Sorting and trimming
4. Cutting/chopping (4-6 pieces)
5. Heating at 90°C for 15 min (to soften)
6. Pulping /extraction of juice
7. Cooking pulp with one third quantity of sugar
8. Putting spice bag into the pulp and pressing occasionally
9. Cooking to one third of original volume of pulp
10. Removal of spice bag

Fig 113: Tomato sauce

11. Addition of remaining sugar and salt
12. Cooking
13. Judging end point (using hand refractometer. TSS: min 25%)
14. Add vinegar and preservative
15. Filling hot (about 88°C) into sterilized bottles
16. Crown corking
17. Pasteurization (in boiling water for 20-30 min)
18. Cooling
19. Storage

FPO Specification: Min TSS 25%, Minimum tomato solid 12 %, Acidity as acetic acid: 1%, Sodium benzoate maximum 750 ppm.

Machineries and Packaging Materials

Machineries
Blanching machine (steam/hot water)
Pulper (with inbuilt SS strainer)
Steam jacketed kettle with agitator
Boiler (electric/diesel operarated)
Semi-automatic /automatic paste filling machine
Automatic pouch filling and sealing machine
Crown corking machine
Bottle sterilization unit
Weighing balance
Refractometer

Packaging Materials
Laminated PP
Heat stable glass bottles
Tin Cans
PET bottles

Fig 114: Pulper

Fig 115: Steam Jacketed Kettle

Fig 116: Automatic Paste Filling Machine

Fig 117: Fill-Seal Machine for Tomato Sauce

2.11. Potato

2.11.1. Introduction

Fig 118: Potato

Potato is semi-perishable vegetable. Basically Potato carries enormous amount of Starch, some Protein, little fat and rich in mineral, vitamin. Therefore, post-production management in potato is as important as the production management. Under tropical and subtropical conditions, 40-50% losses occur due to poor handling and storage. Therefore, it is of utmost importance, to minimize postharvest losses. For successful postharvest management of potato, the farmers should have a better understanding of the production-storage-demand system. Good postharvest management increases returns to the growers. Therefore, the farmers should have access to market information and the ability to take advantage of the market needs. For this access to efficient transport system is very important. Whether to sell the potatoes immediately after harvesting or to store them and, if the potatoes are to be stored, how to store them, and how long to store them are commercial decisions which the potato growers have to take. Postharvest losses cannot be avoided completely. Good postharvest management minimizes losses, while bad post-harvest management results in high storage losses.

Processing of potatoes 'is advantageous, because it makes storage easier due to reduction in bulkiness and increase in shelf-life. It adds value to potatoes and, therefore, gives better returns. From the consumer point of view, all processed products should have an attractive color, acceptable texture and good flavor. Generally, use of high quality potatoes will help to obtain

and maintain good quality of the processed products. Potato processing quality, in turn, is dependent on various conditions, including cultivation and environment as well as the time of harvest. The variety of the potatoes used also is an important factor. Potatoes are processed into many types of products, (i) fried products such as wafers/chips etc.; (ii) dehydrated products such as dice etc.; (iii) frozen products such as French fries, patties, puffs, dice etc.; and (iv) canned.

2.11.2. Important Considerations in Processing Potato

Processors of potatoes should identify long dormancy varieties with round or oval tubers of medium to large size with fleet eyes and free from diseases and peeling losses. The dry matter content of the tubers should be high for greater yield of dehydrated products. The sugar and phenol content should be low and the tubers should be free from after cooking darkening. In addition to the morphological characters, some other factors determining the suitability of potatoes for processing are the specific gravity, or the dry matter content of potatoes and their sugar content. Potatoes, high in specific gravity (or dry matter) are preferred for preparation of chips, French fries or dehydrated products, whereas those of lower specific gravity .are used for canning or for such other products where a firm piece is desired. Yield of chips and flour etc. is higher from high specific gravity potatoes. Besides high yields of the product, the uptake of fat or oil during frying is lower. Moreover, relatively much less moisture has to be removed per unit of products when high specific gravity potatoes are used. However, potatoes of very high specific gravity may not be suitable for the production of French fries etc. French fries produced from potato with a specific gravity of 1.106 were too hard and biscuit like. It is also of the opinion that very high specific gravity potatoes may yield 'hard chips'. Dry matter content (specific gravity) is vital in terms of yield, of potato chips or wafers, and the texture of potato chips and reconstituted dehydrated potatoes. Generally even small (marginal) increases in dry weight, will ensure greater yield of the product. Specific gravity of potatoes can be determined by a number of methods e.g. use of i) brine solution of known specific gravities (Burton 1989), ii) Potato Hydrometer, iii) Archemides principle (Nissen 1967), iv) variable load hydrometer (Sukumaran and Ramdass 1980), and v) ordinary scales (Misra 1983). Dry matter content of fruits and vegetables, including potatoes is determined by oven drying, but a non-destructive method is also available for potatoes and sweet potatoes. Von Schee et al. (1937) demonstrated that the specific gravity and dry matter content of potatoes are directly related to each other. Since then relationships have been established in other countries including India.

Sugar Content

Sugar content of potatoes influences the colour of the processed products and plays a very important role in determining the acceptability of fried products. Chips and French fries prepared from potatoes containing large amounts of sugars, especially reducing sugars, i.e. glucose and fructose, turn brown and black and become 'unacceptable to the consumers. This discolouration is ascribed to a reaction, between the reducing sugars and amino acids, which takes place when the moisture content is low and the temperature is high. Generally, freshly har- vested mature

potatoes contain-acceptable levels of reducing sugars but when stored at low temperatures, the sugar content increases and potatoes become unfit for processing. For storage of potatoes for the processing industry, the current storage practices followed in India are not suitable, as potatoes stored below SOC are rendered unfit for processing due to an increase in reducing sugars. One of the methods of overcoming this problem is to store the potatoes at high temperature. It has been shown that when potatoes were stored at ambient temperatures, there was very little increase in the reducing sugar content of potatoes. But under such conditions sprouting and weight loss were excessive. However, when potatoes were stored in an evaporative cooled store, similar changes in the sugar content were observed but with a lower weight loss of the potatoes, yet the problem of sprouting remained. To overcome this problem, potatoes were treated with CIPC (Isopropyl-N-chlorophenyl carbamate) and stored in an evaporatively cooled store, and also at lower temperatures recommended for storage of potatoes meant for processing. Even under such conditions of storage, potatoes became unfit for processing within a very short period. Recourse had to be taken to reconditioning another method used to overcome the problem of excess sugar in cold stored potatoes. During reconditioning, cold stored potatoes are stored at 15- 20°C for 2-3 weeks. Under such conditions a reduction in the contents of sugars take place. However, in many cases this was also not very effective and dark colored chips were produced. In an attempt to produce acceptable colour, the chips were fired at lower temperatures. While the colour of chips was acceptable the oil content of the chips so produced was about 30% higher than the oil content of chips produced by frying under the normal conditions. The discolouration of chips and French fries due to high sugar content of cold stored potatoes is a problem faced by the industry all over the world and attempt have been made to identify varieties which do not accumulate large amount of sugars during the low temperature storage. In UK, a variety Brodick has been released and in India, Kufri Sherpa has been found to accumulate much lower quantities of sugars than many other potato varieties (Kufri Badshah, Kufri Chandrarnukhi, Kufri Jyoti, and Kufri Sindhuri) examined.

Discolouration

One of the problems affecting appearance and acceptability of any potato product is the tendency for discolouration or browning. This is generally a result of physiological conditions, and some subsequent chemical reactions. Potato and potato products are prone to three types of discolouration: enzymatic discolouration, after cooking discolouration and discolouration of fried products (Chips/Wafers/French fries) and dehydrated potatoes.

I. **Enzymatic Discolouration**: Discolouration of peeled or cut raw potatoes results from enzymatic oxidation and Discoloration of polyphenolic compounds in the presence of air or oxygen. The problem is encountered in sun-drying of potatoes and is due to the action of polyphenoloxidase enzyme on the phenolic compounds. Similar reaction takes place in the development of black spot in potatoes during harvesting, handling and transport, especially at low temperatures. Exclusion of oxygen or preventing contact of the potatoes with air can prevent discolouration. Inactivating the enzyme with heat or lowering the pH

also helps to control browning. An alternative way is to treat the whole potato with So2 gas. Such potatoes can be stored. High concentrations of CO2 can also be used to treat whole potatoes to prevent the accumulation of reducing sugar and to improve the colour of wafers. Storage of potatoes also influences enzymatic browning. Generally, higher temperatures and longer storage periods has been associated with higher levels of tyrosine; thus, such potatoes tend to be more discoloured when peeled or cut. Enzymatic discolouration and black spot in potatoes can also be prevented by the application of potassium fertilizers specially muriate of potash. But the application of muriate of potash resulted in a decrease of the dry matter content of potatoes. Therefore, the industry uses other methods to overcome the problem of enzymatic discolouration, i.e., the application of chemicals to peeled potatoes. Sulfating, as the common procedure is known as, helps to reduce or eliminate enzymatic browning but is a potential health hazard, specially to people prone to asthmatic conditions. As such efforts have been made to select varieties which do not show any enzymatic discolouration. It has been reported that varieties 02286 and C2703 did not show much enzymatic discolouration.

II. **After Cooking Discolouration (ACD)**: As the term suggests, it develops in cooked potatoes and potato products after exposure to air, especially in boiled and steamed potatoes. Discoloration and / or darkening occurs after cooking due to the non enzymatic browning reactions which take place at high temperatures used in preparation of chips/wafers, French fries, canned potatoes or during dehydration. After cooking darkening is, generally, due to the formation of a dark coloured complex of ferric iron and a phenolic compound. Factors such as iron content, presence of organic acid, pH and phenolic compounds are involved in such darkening, which usually, is less in immature than in mature tubers. In solutions more acidic than the normal pH of potatoes, the darkening can be prevented; while, in contrast, it is intensified by reactions which are alkaline. The organic acid content, aspartic acid, of the tubers affects the discolouration after cooking. This has been attributed due either to the effect of pH, or the ability of the acid to chelate iron and compete with chlorogenic acid for iron, and form a colourless complex. The more the citric acid, the lesser the content of darkening. Thus, darkening is associated with low levels of organic acid, such as citric, oxalic, malic and orthophosphoric acids. It has been suggested. however, that the amount of free organic acid is a greater determinant for discolouration. Almost all the Indian potato varieties are free from ACD, though it has been observed occasionally in Kufri Jyoti. But ACD develops in gamma irradiated potatoes stored at or below 15°C for 2.5 to 3 months. The problem could be overcome by storing potatoes at higher temperature or by reconditioning such potatoes at 30-35°C for 2 weeks.

III. **Discolouration of Fried Products and Dehydrated Potatoes**: Products made from potatoes with high sugar content are more likely to be scorched, or discoloured during

dehydration and to turn dark during storage. Two methods have been suggested for overcoming the problem. In one of the methods, excess quantity of sugars is fermented to lactic acid by Lactobacillus plantarum L.nd it was claimed that "Satisfactory product, with respect of colour, flavour/aroma, texture and general acceptability could be produced by this method". In another method, thereactants were removed by repeated washing of the raw slices in water. It was claimed that about 50% of the reducing sugars and about 40% of the free amino acid were removed by washing the raw slices in water. It may be pointed out that these two reactants are involved in the development of the discolouration of fried products.

2.11.3. Processing and Value Addition of Potato

2.11.3.1. Potato Chips/Wafers

Raw Materials: Good quality potato (Round to round-oval, tuber size 40-60 mm) edible refined oil, salt.

Process Flow

1. Potatoes (Fully matured, contains less eyes, round-oval shaped)
2. Washing and peeling
3. Trimming (removal of residual skin, green portions and discoloured area)
4. Slicing (2-2.5 mm by suitable slicing machine)
5. Putting the slices in KMS solution (0.05%) then in boiling water for 2-3 min) to avoid browning
6. Slices are then subjected to hydro extracting machine to drain the surface water
7. Frying in continuous or batch fryer (180 ° C for 3-4 min /till it becomes golden crisp)
8. De-oiling
9. Salting and addition of other flavouring materials
10. Cooling
11. Nitrogen gas packaging

Fig 119: Potato Chips

2.11.3.2. French Fries (Frozen)

Indian fast food sector is growing at 25-30 % annually due to rapid growth of fast food chain both Indian and international. Presently, the core food service Indian market is 3600 crores and the share of quick service restaurants' is Rs. 2500 crores. Out of the total snacks, potato based products like French fries, wedges, products using potato flakes and other Indian snacks have about 30 % share in fast food industry, approximately 75 crores in value terms. French fries are among the highest saleable potato products. This is the most abundant processed potato and can be found in many varieties such as lattice cut, wedges, curly, batter dipped, seasoned, or straight

–cut including French Fries on menu is one of the easiest ways to increase sales and profits for the companies.

Raw Materials: Fully matured potatoes (long tuber), edible refined oil

Process Flow

1. Potatoes (Fully matured, contains less eyes, oval-long tuber)
2. Washing and peeling
3. Trimming (removal of residual skin, green portions and discoloured area)
4. Cutting into long strips (using strip cutter)
5. Sorting (Removal of broken/defective strips)
6. Blanching (Putting the strips in boiling water for 2-3 min to avoid browning)
7. Strips are then subjected to hydro extracting machine to drain the surface water
8. Frying in continuous or batch fryer (180 ° C for 3-4 min /till it gets desirable quality)
9. De-fatting
10. Air cooling
11. Packaging
12. Freezing (-18°C)
13. Storage

Fig 120: French Fry

2.11.3.3. Dehydrated Potato and Potato Flour

Dehydration of potato can also reduce wastage percentage. It is a very easy process to store potato for long time. Dehydrated potato can be used by rehydrating it in water. Potato flour is also a very important product and is used in the baking industry, mainly to reduce the protein content of the mix, but also to impart softness to bread and for better retention of moisture. Potato flour can also be used to partially replace wheat flour in the preparation of biscuits and 'Chaptai', respectively. It is used as a base for the preparation of many soup mixes.

Raw Materials: Fully matured potatoes (long tuber), water.

Process Flow

1. Potatoes (Fully matured, contains less eyes, oval-long tuber)
2. Washing and peeling
3. Trimming (removal of residual skin, green portions and discoloured area)
4. Slicing (3-4mm by suitable slicing machine) /Dicing
5. Blanching (Putting the slices in KMS solution (0.05%) then in boiling water for 2-3

Fig 121: Potato Flour

min)
6. Draining of water
7. Dehydration (Sun/Tray drier)
8. Packaging/ Grinding and packaging
9. Storage

2.11.3.4. Potato Papad

Raw Materials: Potato - 1 kgs (medium sized)**;** Salt - less than 1 tea spoon (according to the taste)**;** Red Chili Powder - less than a 1/2 tea spoon; Oil - 2 table spoon.

Process Flow

1. Potatoes (Fully matured, contains less eyes, oval-long tuber)
2. Wash and boil the Potatoes in the cooker in 2 cups of water for up-to 1 whistle
3. Once the Potatoes are boiled and cools down, peel and grate them.
4. Add salt, red chili powder into the grated Potatoes and mash them
5. Make 20-22 balls from the mixture of 1 kg potatoes
6. Rolling on a greased polythene sheet
7. Drying
8. Packaging
9. Storage

Fig 122: Potato Papad

Machineries and Packaging Materials

Machineries
Potato Peeler(with water cleaning system)
Washing tank
Potato slicer (Slicing, dicing, and Strip cutting. Material SS))
Blanching machine (SS)
Spinning Hydro Extractor
Deep fat fryer (batch/continuous)
Salting drum
Nitrogen packing and sealing machine (Automatic/semiautomatic) with nitrogen cylinder
Electric tray dryer
Hammer mill (for making powder)
Pouch sealing machine (Automatic/semi automatic)
Deep freezer

Packaging Materials
PE/PP
Laminated PP

Fig 123: Potato peeler

Fig 124: Potato Slicer

Fig 125: Deep Fat Fryer

Fig 126: Nitrogen Packing machine for Chips

2.12. Pineapple

2.12.1. Introduction

North-East India is considered as the most potential area for pineapple production in India. Owing to the suitable climatic conditions of acidic sloppy soil and humid cold air, the quality and taste of pineapple of this region stands out. The smaller size queen pineapple is profusely grown here and has a significant amount of production in total national data. Various products which can be made out of pineapple are explained below:

Fig 127: Pineapple

2.12.2. Processing and Value Addition of Pineapple

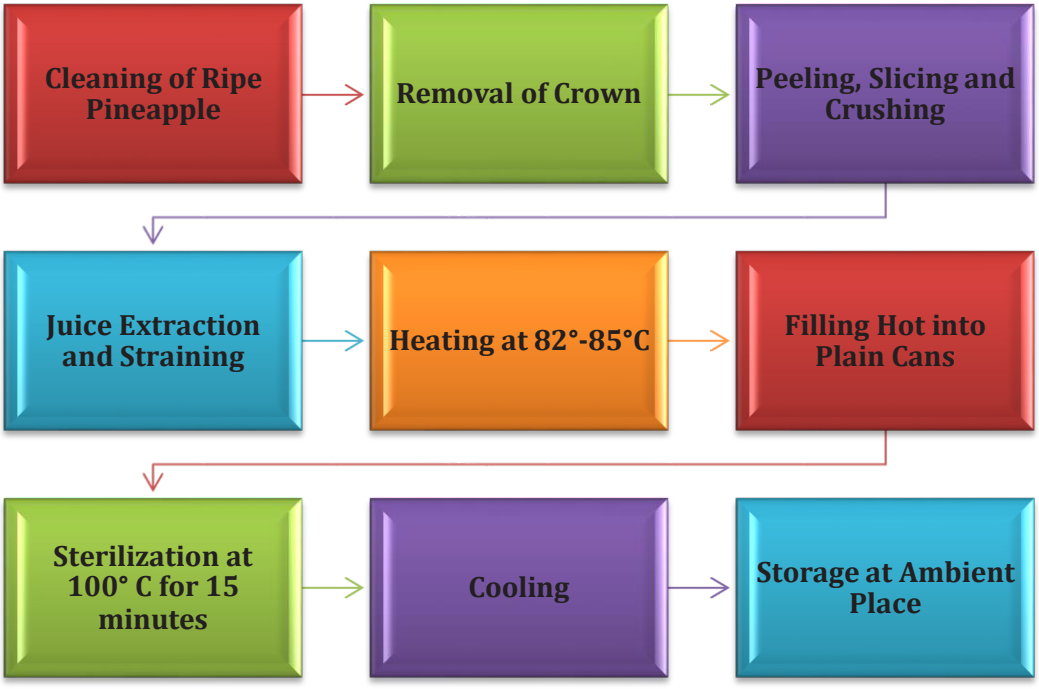
2.12.2.1. Pineapple Juice

FSSAI Specification for Juice: Juice may be pure with natural sugar or sweetened, which has 10 per cent total soluble solids and 85% juice. FSSAI specifications for unsweetened juice are: (i) minimum per cent of total soluble in natural content, (ii) minimum percent of fruit juice 100 per cent. The permissible limit of preservative as sulphur dioxide/KMS 350 ppm. FSSAI specification for sweetened juice is:(i) minimum percent of total soluble solid is 10 and (ii) minimum per cent of fruit juice 85. The permissible limit of preservative as sulphur dioxide/KMS 350 ppm.

Fig 128: Pineapple Juice

Ingredients: Ripe Pineapple, KMS

Process Flow



Machineries
Fruits and Vegetables Washer
Pineapple Peeler
Slicer
Fruit Crusher and Juice Extractor
Steam Jacketed Kettle
Boiler

Packaging Materials
Glass bottles, PET bottles, Polypropylene (PP) bottles, Tetrapack (for aseptic packaging), Laminated and Pouted Pouches

Can Filler
Sterilizer/ Retort/ Autoclave
Cooling Chamber
Bottling Filling Machine
Crown Corking Machine
Labelling Unit
Cold Storage
Brix meter

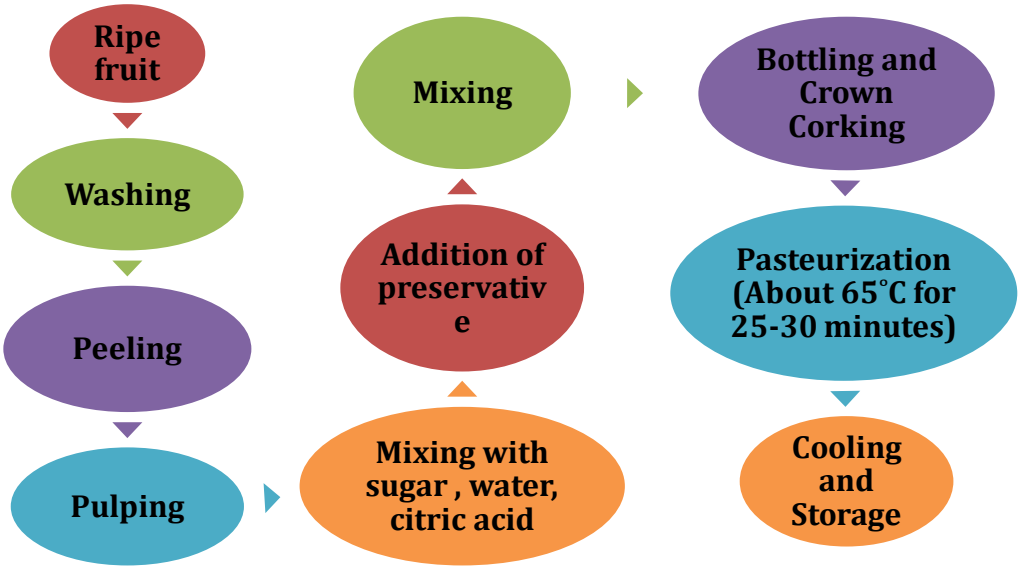
2.12.1.2. Pineapple Ready-To-Serve Beverage

FSSAI Specification: Ready-to-serve beverages are the most popular bottled products which contains at least 10% fruit juice and 10% total soluble solids. FSSAI specifications for ready-to-serve beverage are: (i) minimum percent of TSS 10 and (ii) minimum % of fruit juice 10 except lime juice (5%).The permissible limit of preservative as sulphur dioxide/KMS 70ppm and as benzoic acid/ sodium benzoate 120ppm. Acidity of the juice should be 0.3%.

Fig 129: Pineapple RTS

Ingredients: For 1 kg of RTS, Extracted juice: 100 g (Min.), Sugar: 100 g, Citric Acid: 3 g, Water: 800 ml, KMS: 0.07 g or Sodium benzoate: 0.12 g.

Process Flow



Machineries
Fruits and Vegetables Washer
Pineapple Peeler
Slicer
Fruit Pulper with Strainer
Steam Jacketed Kettle
Boiler
Sterilizer/ Retort/ Autoclave
Cooling Chamber
Bottling Filling Machine
Crown Corking Machine
Labelling Unit
Cold Storage
Brix meter

Packaging Materials
Glass bottles, PET bottles, Polypropylene (PP) bottles, Tetrapack (for aseptic packaging), Laminated and Pouted Pouches

2.12.1.3. Pineapple Nectar

Fig 130: Pineapple Nectar

FSSAI Specification: This is a type of fruit beverage which contains at least 20% fruit pulp/juice and 15% TSS. Experiences however shown that nectar prepared with 15% sugar is very sweet. It has normally 0.3% acidity. Dilution is not required before serving. The most suitable fruits for preparation of nectar are papaya, mango, peach, and apricot. FSSAI specifications for nectar are: (i) minimum percent of TSS 15 and (ii) minimum percent of fruit juice 20% except pineapple and orange (40). The permissible limit of preservative as sulphur di-oxide 70 ppm and benzoic acid 120 ppm.

Ingredients: For 1 kg of Nectar, Extracted juice: 200 g (Min.), Sugar: 150 g, Citric Acid: 3 g, Water: 650 ml, KMS: 0.07 g or Sodium benzoate: 0.12 g.

Process Flow

Machineries
Fruits and Vegetables Washer
Pineapple Peeler
Slicer
Fruit Pulper with Strainer
Steam Jacketed Kettle
Boiler
Sterilizer/ Retort/ Autoclave
Cooling Chamber
Bottling Filling Machine
Crown Corking Machine
Labelling Unit
Cold Storage
Brix meter

Packaging Materials
Glass bottles, PET bottles, Polypropylene (PP) bottles, Tetrapack (for aseptic packaging), Laminated and Pouted Pouches

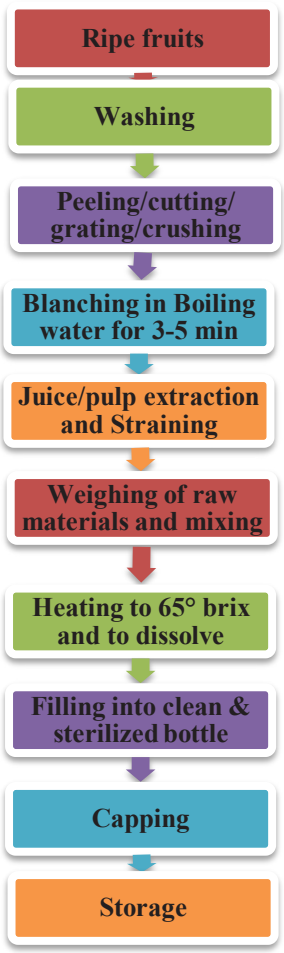
2.12.1.4. Pineapple Syrup

FSSAI Specification: A type of fruit beverage contains at least 25% fruit juice/pulp and 65% total soluble solids with about 1.3% acidity. FSSAI specifications for syrup are: (i) minimum percentage of total soluble solids 65 and (ii) minimum percentage of fruit juice 25. The permissible limit of the preservative as sulphur dioxide and benzoic acid are 350 ppm and 600 ppm respectively.

Ingredients: For 1 kg of Syrup, Extracted juice: 250 g (Min.), Sugar: 600 g, Citric Acid: 13 g, Water: 150 ml, KMS: 0.35 g or Sodium benzoate: 0.6 g.

Process Flow Chart

Fig 131:



Machineries and Packaging Materials

Machineries
Fruits and Vegetables Washer
Pineapple Peeler
Slicer
Fruit Pulper with Strainer
Steam Jacketed Kettle
Boiler
Sterilizer/ Retort/ Autoclave
Bottling Filling Machine
Crown Corking Machine
Labelling Unit
Cold Storage
Brix meter

Packaging Materials
PET bottle, Glass bottles, PP Bottles

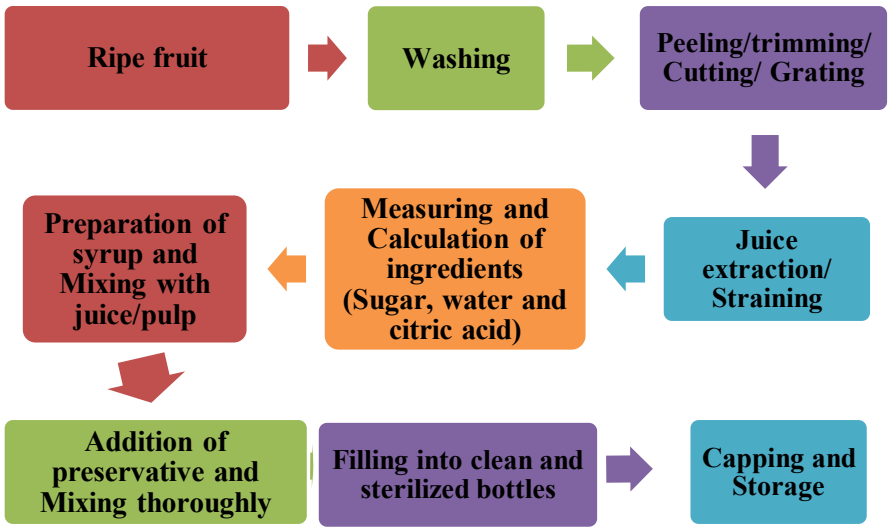
2.12.1.5. Pineapple Squash

Fig 132: Pineapple Squash

FSSAI Specification: A type of fruit beverage which contain at least 25% percent juice and 40% total soluble solids. It also contains about 1% acidity and 350ppm sulphur dioxide and 600ppm sodium benzoate (in coloured juices). It is diluted before being served. FSSAI specifications for squash are: (i) minimum per cent of total soluble solids 40 and (ii) minimum per cent of fruit juice 25. The permissible limit of the preservative as sulphur dioxide 350 ppm or as benzoic acid 600 ppm.

Ingredients: For 1 kg of Squash, Extracted juice: 250 g (Min.), Sugar: 400 g, Citric Acid: 10 g, Water: 350 ml, KMS: 0.35 g or Sodium benzoate: 0.6 g.

Process Flow



Machineries and Packaging Materials

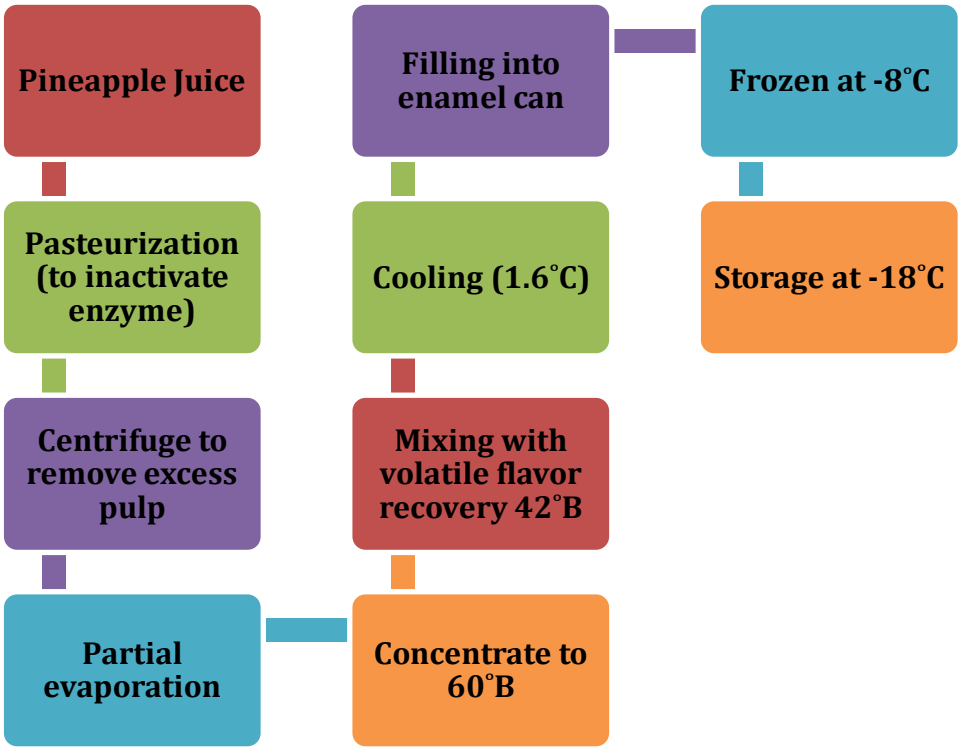
Machineries	Packaging Materials
Fruits and Vegetables Washer, Pineapple Peele, Slicer, Fruit Pulper with Strainer, Steam Jacketed Kettle, Boiler, Sterilizer/ Retort/ Autoclave,Bottling Filling Machine, Crown Corking Machine, Labelling Unit, Cold Storage, Brix meter	PET bottle, Glass bottles, PP Bottles

2.12.1.6. Pineapple Juice Concentrate

FSSAI Specification: This is a fruit juice, which are concentrated by removal of water either by heat or by freezing. Removal of water in order to concentrate the juice by heating is economically most favourable and widely used. Fruit juice concentrate contains at least 32% total soluble solids. Fruit juice concentrate is easier to handle during packaging, transport and storage due to reduced weight and bulk. Fruit juice concentrate can be used for preparation of various types of beverage including carbonated beverage. Fruit juice concentrate can be prepared from various fruits.FPO specifications for fruit juice concentrate are: (i) minimum percentage of total soluble solids 32 and (ii) minimum percentage of fruit juice 100. The permissible limit of the preservative as sulphur dioxide 1500 ppm.

Ingredients: Concentrated Fruit Juice (32% TSS), KMS: 1.5 g/ kg concentrate

Process Flow



Machineries and Packaging Materials

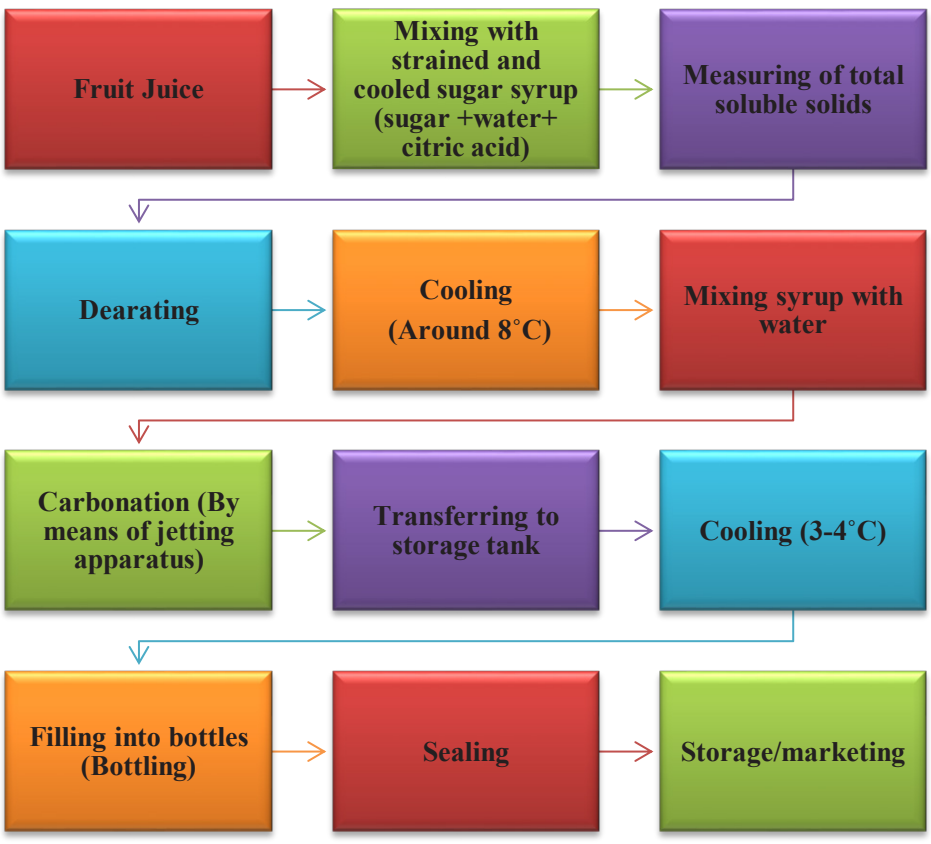
Machineries	Packaging Materials
Fruits and Vegetables Washer, Pineapple Peeler, Slicer, Fruit Pulper or Juicer with Strainer, Steam Jacketed Kettle, Boiler, Pasteurizer, Centrifuge, Evaporator and Condenser, Can Filling Machine, Crown Corking Machine, Brix meter, Deep Freezer	Can, Glass bottles, PP Bottles

2.12.1.7. Pineapple Carbonated Beverage

Fruit based syrup such as pineapple, orange, lime, grape and guava can be used for carbonated soft drink. Principally fruit juice based carbonated soft drink processing is a mixture procedure with fruit juice, sugar, water, acid and carbon dioxide. The secret of a recipe basis lies in harmonizing the raw materials in such a way that the finished product has refreshing stimulation character.

Ingredients: Pineapple fruit juice, sugar, water, acid and carbon dioxide**.**

Process Flow



Machineries and Packaging Materials

Machineries
Fruits and Vegetables Washer, Pineapple Peeler, Slicer, Fruit Pulper or Juicer with Strainer, Steam Jacketed Kettle, Boiler, Dearation Tank, Cooling Tank, Mixing Tank, Carbonation Unit, Bottle Filling Machine, Sealing Machine, Brix meter, Deep Freezer

Packaging Materials
Can, Glass bottles, PP Bottles

2.12.1.8. Dehydrated Pineapples

Ingredients: Pineapple, Sulphur Gas

Process Flow

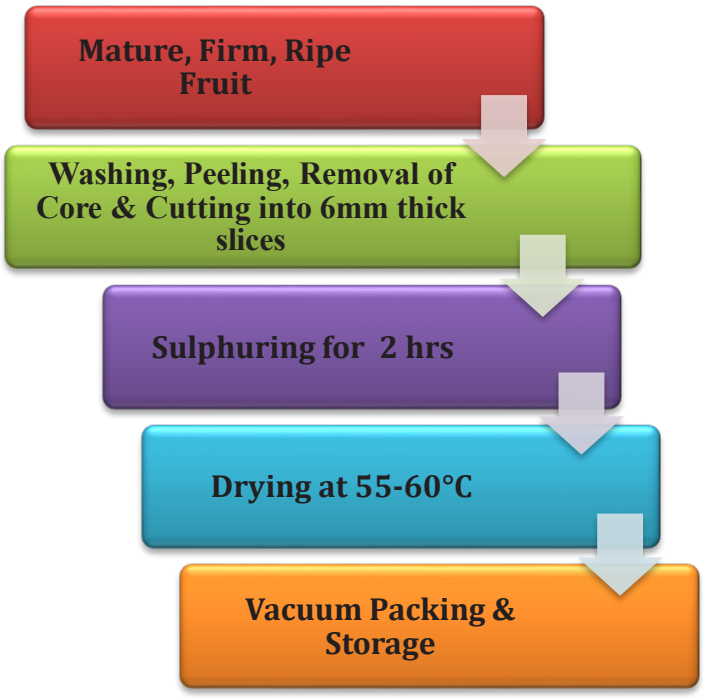


Fig 133: Dehydrated Pineapple

Machineries and Packaging Materials

Machineries
Fruits and Vegetables Washer, Pineapple Peeler, Slicer, Sulphuring Gas Unit, Tray Dryer, Vacuum packaging Machine

Packaging Materials
LDPE Pouches, Laminates

2.12.1.9. Pineapple Jam

FSSAI Specification: Jam is a product obtained by cooking fruit pulp with sugar and acid to a desired consistency. Jam contains 0.5-0.6 percent acidity and 68% total soluble solids. Jam can be prepared from several fruits such as: Apple, Aonla, mango,Pear, Papaya, Strawberry, Goose berry, Pineapple. FPO specification for jam is (i) minimum per cent of total soluble solids in final product 68 and (ii) minimum per cent of fruit juice in final product should be 45.

Ingredients: Fruit pulp: 1 litre, Sugar: 800gm, Citric acid: 6g, Sodium benzoate: 1g

Process Flow

1. Ripe fruit
2. Washing
3. Peeling
4. Cutting/grating and pulping
5. Addition of Sugar and water
6. Cooking upto desired consistency
7. Addition of citric acid
8. Judging the end point by temperature (105°C) or TSS (68-70%)
9. Filling hot into clean and sterilized bottles
10. Cooling
11. Waxing
12. Capping
13. Storage in a cool and dry place

Fig 134: Pineapple Jam

Machineries and Packaging Materials

Machineries
Fruits and Vegetables Washer, Pineapple Peeler, Slicer, Fruit Pulper, Steam Jacketed Kettle, Boiler, Bottle Filling Machine, Lug Cap Sealing Machine, Brix meter

Packaging Materials
Glass bottles, PP bottles

2.12.1.10. Pineapple Jelly

FSSAI Specification: Jelly is a semisolid product obtained by boiling a clear strained fruit juice with sugar and acid to a thick consistency. Jelly contains total soluble solids not less than 65 percent and acidity 0.5 to 0.7 per cent.FPO specification for fruit jelly are (i) Minimum percentage of total soluble solid in final product is 65 and (ii) minimum percent of fruit juice in final product should be 45.

Ingredients: Fruit juice: 1 litre, Sugar: 800g, Citric acid: 6g, KMS: 2g

Process Flow

1. Fruit(firm not over ripe)
2. Washing & Cutting into thin Slices
3. Boiling with water(one and half time the weight of fruit for 20-30 minutes)
4. Addition of citric acid while boiling(2g/kg fruit)
5. Straining of extract
6. Pectin test for addition of sugar (jell meter test)
7. Addition of sugar & Cooking
8. Judging the end point by temperature (105°C) or TSS (68-70%)
9. Judging of end point by temperature (105°C) or TSS (65%) or sheet or drop test
10. Removal of scum foam & Add remaining citric acid
11. Filling hot in clean and sterilized bottles
12. Wiping & Capping
13. Storage

Fig 135: Pineapple Jelly

Machineries and Packaging Materials

Machineries
Fruits and Vegetables Washer, Pineapple Peeler, Slicer, Fruit Pulper, Steam Jacketed Kettle, Boiler, Bottle Filling Machine, Lug Cap Sealing Machine, Brix meter.

Packaging Materials
Glass bottles, PP bottles, PP pouches

2.12.1.11. Frozen Pineapple

Freezing is a low temperature preservation process where the product is frozen at -40° C and stored at -20° C. Freezing is cheaper than canning and frozen products are close to fresh products or of better quality. The metabolic activity and spoilage due to post harvest chemical changes are retarded by freezing. Though the product preserved by freezing retains their quality appreciably, the major disadvantage of the technique is that the low temperature has to be maintained during handling, transportation and storage before the product is finally consumed. There are various methods of freezing viz., plate freezing, blast freezing and Individual Quick Freezing (IQF), which are commercially used for placed in contact with a cold surface. This process is suitable for packaged food products. Blast freezing refers to vigorous circulation of cold air for freezing the product. The air temperature is about -18° C to -30° C or even lower. This process is cheaper and variety of sizes and shapes can be accommodated. Individual Quick Freezing involves the fluidization of the product in the freezing conveyor and circulating cold air at-40° C. The advantages of IQF are reconstitution properties due to quick freezing. Frozen fruit/vegetable products may also be exported.

Ingredients: Pineapple pieces, Sugar, Water, Ascorbic Acid: 5g/ kg sugar solution, Citric Acid: 3 g/ kg sugar solution

Process Flow

1. Fruit(firm not over ripe)
2. Washing
3. Peeling
4. Cutting into slices
5. Filling into polythene bag
6. Covering with 40° B sugar syrup containing 0.3% citric and 0.5% ascorbic acid
7. Sealing of polythene bag
8. Placing in waxed cartons
9. Freezing at -40° C
10. Storing at -20° C

Fig 136: Frozen Pineapple

Machineries and Packaging Materials

Machineries
Fruits and Vegetables Washer, Pineapple Peeler, Slicer, Filling Machine, Steam Jacketed Kettle for Sugar Syrup, Boiler, IQF, Deep Freezer

Packaging Materials
PE Laminates.

2.12.1.12. Pineapple Pickles

Pineapple pickles are other value added products. It can be prepared from peeled pineapple, cloves, cinnamon, ginger, sugar, white vinegar and chilli powder. Pineapple pickles can be both sweet and sour types.

2.12.1.13. Pineapple Fruit Bar

Pineapple fruit bar is made by drying pineapple pulp sheet mixed with sugar, pectin, citric acid and KMS and then cutting the sheets into small bars. Bars are wrapped in cellophane paper and polythene pouches. It has a sweet taste and a characteristic flavour. Fruit paste is more nutritious than common sweets made solely from sugar and artificial flavours.

Ingredients: Pineapple pulp, sugar, pectin, citric acid and KMS

Process Flow

1. Extraction of pineapple pulp
2. Addition of sugar
3. Cooking up to desired consistency
4. Spreading on greased tray
5. Drying
6. Cutting in to desirable pieces
7. Packaging
8. Storage

Fig 137: Pineapple bar

Machineries and Packaging Materials

Machineries
Pineapple Cutting and Peeling machine, Pineapple Pulper Steam Jacketted Kettle, Baby Boiler, Mechanical Dryer, Sheeting and Cutting machine.

Packaging Materials
PE Laminates.

2.12.1.14. Pineapple Preserve, Candy and Glazed Fruit

Preserve is a mature fruit or fruit pieces impregnated with sugar till it becomes tender and transparent. Sugar syrup should have 68-70% concentration. FPO specification for fruit preserves are: (i) minimum 68 % of total soluble solids (TSS) in the final product (W/W) and (ii) minimum 55 % of prepared fruit in final product (W/W). Recipes for pineapple preserve are mature pineapple and sugar.

Ingredients: Pineapple fruit pieces, sugar.

Process Flow

1. Washing and peeling pineapple
2. Cutting into pieces
3. Addition of ground sugar in alternative layer
4. Keeping over night
5. Taking out of sugar syrup
6. Concentrate the syrup up to 68 degree brix
7. Again put the pieces in to syrup and keep over night
8. Taking out the pieces from syrup
9. Prepare fresh sugar syrup of 68 degree brix & put the pieces again in it.
10. Packaging and storage

Fig 138: Pineapple preserve

Pineapple Candy is prepared by putting pineapple fruit impregnated with sugar and subsequently drained and dried. Preservation of fruit in the form of candy or use of high concentration of sugar in the form of syrup is one of the traditional methods to preserve fruits. FPO specification for candied fruits is: (i) total sugar not less than 70%, (ii) reducing sugar (as % of total sugar) is not less than 25%. Recipes for pineapple preserve are mature pineapple and sugar.

Ingredients: Pineapple fruit pieces, sugar

Process Flow

1. Washing and peeling pineapple
2. Cutting into pieces
3. Addition of ground sugar in alternative layer
4. Keeping over night
5. Taking out of sugar syrup
6. Concentrate the syrup up to 68 degree brix
7. Again put the pieces in to syrup and keep over night
8. Taking out the pieces from syrup
9. Washing with water and drying
10. Packaging and storage

Fig 139: Pineapple Candy

Glazed Fruit is a candied fruit dipped for a moment in boiling syrup to impart a glossy finish, drained and dried. The fruits which are suitable for candy are also suitable for making glazed fruits. FPO specifications for glazed fruit are same as for candied fruits.

Ingredients: Pineapple fruit pieces, sugar

Process Flow

1. Washing and peeling pineapple
2. Cutting into pieces
3. Addition of ground sugar in alternative layer
4. Keeping over night
5. Taking out of sugar syrup
6. Concentrate the syrup up to 68 degree brix
7. Again put the pieces in to syrup and keep over night
8. Taking out the pieces from syrup
9. Drying
10. Packaging and storage

Fig 140: Pineapple Glazed Candy

Machineries and Packaging Materials

Machineries	Packaging Materials
Pineapple Cutting and Peeling machine, Steam Jacketted Kettle, Baby Boiler, Mechanical Dryer	PE Laminates.

2.12.1.15. Pineapple Toffee

Toffee can be prepared from pineapple. In toffee preparation, first sieved pulp (1 kg) is concentrated to 1/3 volume and cooked with added sugar (600 gm), glucose (100 gm) and hydrogenated fat (100 gm) upto desired consistency. Then transferred in to a smooth surface container, smeared lightly with fat , spreading into 0.5-0.75 cm thick sheet and allowed to cool and set. Then solid sheet is cut into toffee, wrapped in tissue paper and packed in air tight jar or tin.

Ingredients: Pineapple fruit pieces, sugar

Process Flow

1. Extraction of pineapple pulp
2. Add veg. fat on hot pan
3. Cooking up pulp with sugar up to desired consistency
4. Spreading on greased tray
5. Drying
6. Cutting in to desirable pieces
7. Packaging
8. Storage

Machineries and Packaging Materials

Machineries	Packaging Materials
Pineapple cutting and peeling machine, Pineapple pulper, Steam Jacketed Kettle, Baby Boiler, Mechanical dryer, Sheeting and cutting machine, Packaging Machine	LDPE wrapper

2.13. Banana

2.13.1. Introduction

Banana is a berry type of fruit with herbaceous flowering plant first domesticated in South East Asian countries. All the parts of plant are utilizable for edible as well as non edible purposes. The fruit of banana is rich in dietary fiber, minerals and vitamins. The varieties which are profusely grown in North East India are Jahaji (Dwarf Cavendish), Chini Champa (*Musa chinichampa*), Malbhog (*Musa paradisiaca*, AAB group), Borjahaji (Robusta), Honda, Manjahaji, Chinia (Manohar), Kanchkol, Bhimkol (*Musa balbisiana*), Jatikol, Digjowa, Kulpait and Bharat Moni. Some of the banana products are suggested as under:

2.13.2. Processing and Value Addition of Banana

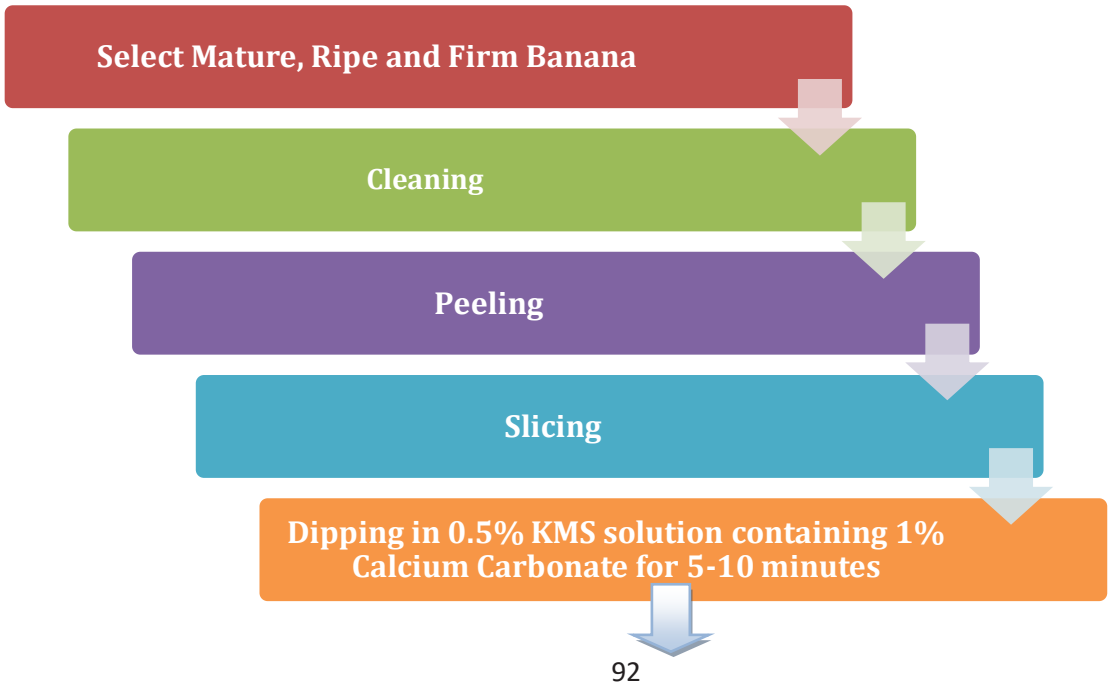
2.13.2.1. Banana Chips

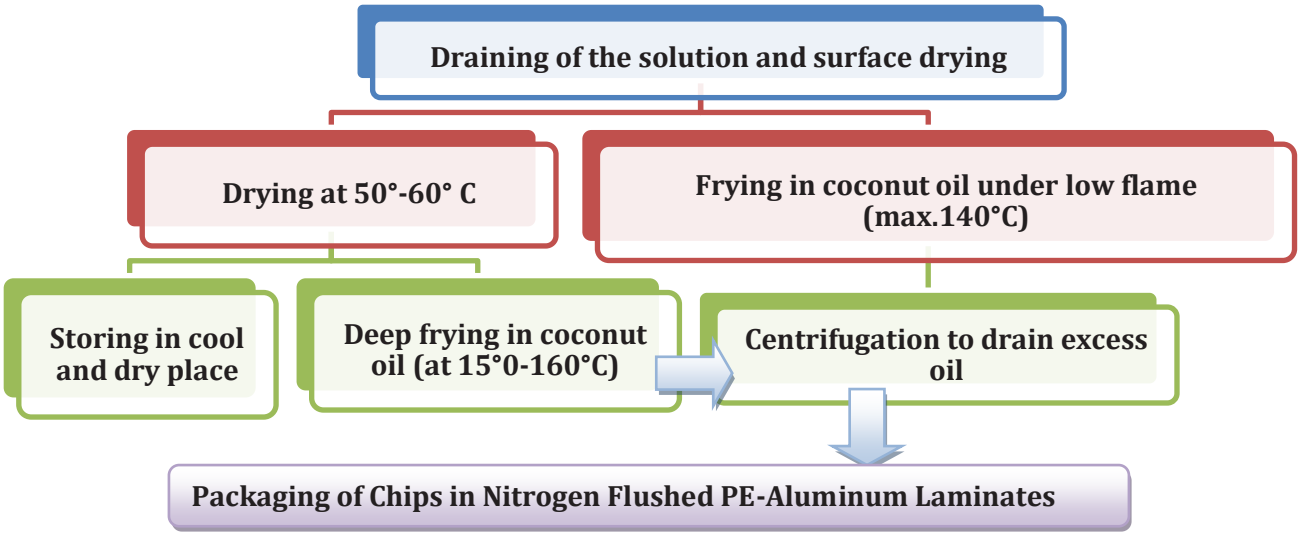
Fig 141: Banana Chips

Chips are major value added product from banana. Banana fruit of 80% maturity is harvested and de-handed. The fingers are peeled and treated with 1% potassium meta-bisulphite, cut into pieces of 0.8-1.2 mm thickness and deep fried in coconut oil or refined vegetable oil. Upon frying this will yield crisp, yellow coloured chips which can be sprinkled with common salt and packed in polyethylene bags.

Ingredients: Banana (preferably Nendran variety), KMS- Food Grade (Potassium Metabisulphite), Calcium Carbonate (Food grade), Water, Coconut Oil

Process Flow





Machineries and Packaging Materials

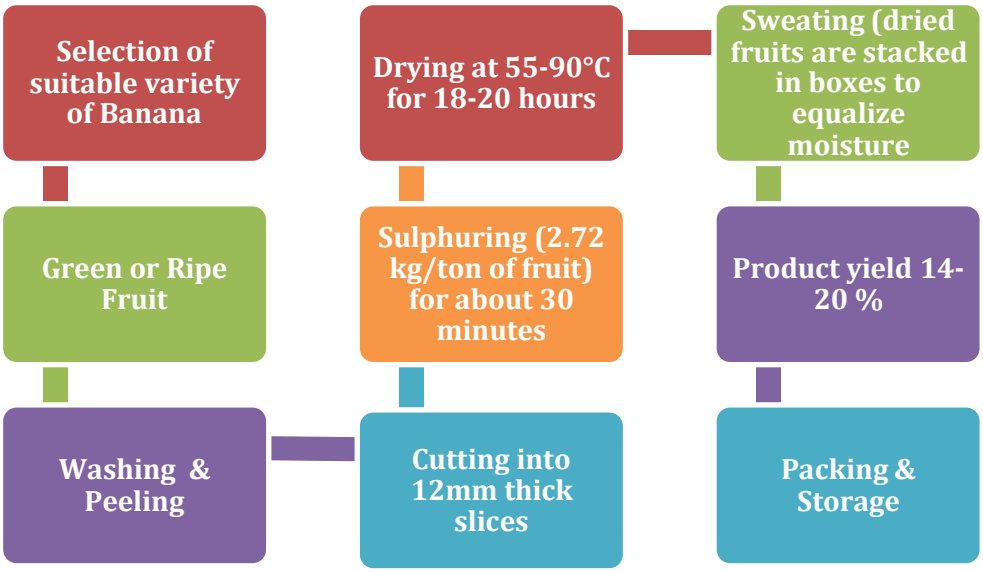
Machineries
Fruits Washer, Peeler, Slicer, Storage Tank, Draining Tank, Dryer, Fryer, Dehumidifier

Packaging Materials
Nitrogen flushing packaging machine (Batch type Band Sealer or Continuous Type Form-Fill-Seal Machine).

2.13.2.2. Dehydrated Chips

Ingredients: Banana, Sulphur Gas

Process Flow



Machineries and Packaging Materials

Machineries	Packaging Materials
Fruits and Vegetable Washer, Peeler, Slicer, Gas Spraying Machine, Tray Dryer	Nitrogen flushing packaging machine (Batch type Band Sealer or Continuous Type Form-Fill-Seal Machine).

2.13.2.3. Banana Toffee

Toffee can be prepared from banana. In toffee preparation, first sieved banana pulp (1 kg) is concentrated to 1/3 volume and cooked with added sugar (600 gm), glucose (100 gm) and hydrogenated fat (100 gm) up to desired consistency. Then transferred in to a smooth surface container, smeared lightly with fat, spreading into 0.5-0.75 cm thick sheet and allowed to cool and set. Then solid sheet is cut into toffee, wrapped in tissue paper and packed in air tight jar or tin.

Ingredients: Pulp: 1 kg, Sugar: 600g, Glucose: 100g, Skim Milk Powder: 160g, Butter or Hydrogenated fat: 100g.

Process Flow

1. Ripe fruits
2. Washing
3. Peeling
4. Pulping
5. Cooking or concentrating (in steam jacketed kettle) to one-third of original volume
6. Addition of other ingredients and mixing
7. Continue cooking till desired consistency
8. Transferring to a smooth surface container (smeared lightly with fat)
9. Spreading into thin sheet (0.5-0.75 cm thick)
10. Allowing cooling and setting
    Solid sheet cut into toffee
11. Wrapping in tissue paper and PE-Al Laminate
12. Storage

Fig 142: Banana Toffee

Machineries and Packaging Materials

Machineries	Packaging Materials
Washer, Peeler, Pulper, Boiler, Steam Jacketed Kettle with stirrer, Holding Sheet Trays, Wire Cutter, Toffee Wrapper Packaging Machine	LDPE wrapper

2.13.2.4. Banana Fruit Bar

Banana fruit bar is made by drying banana pulp sheet mixed with sugar, pectin, citric acid and KMS and then cutting the sheets into small bars. Bars are wrapped in cellophane paper and polythene pouches. It has a sweet taste and a characteristic flavour. Fruit paste is more nutritious than common sweets made solely from sugar and artificial flavours.

Ingredients: Pulp: 1 kg, Sugar: 100g, Citric Acid: 2 g, KMS: 1 g

Process Flow

1. Ripe fruit
2. Washing
3. Peeling
4. Pulping
5. Pulp
6. Heating (83° C for 10 minutes)
7. Mixing with sugar, citric acid and KMS
8. Spreading on tray
9. Drying in cross-flow drier at 60° C until can be taken out in the form of sheet
10. Cutting of sheets into small bars
11. Wrapping in cellophane paper
12. Packing in polythene pouches and storage

Fig 143: Banana Bar

Machineries and Packaging Materials

Machineries
Fruit washing machine, Fruit Cutting and Peeling machine, Fruit Pulper, Steam Jacketed Kettle, Baby Boiler, Mechanical Dryer, Toffee sheeting and Cutting machine, Packaging, Wrapper Packaging Machine

Packaging Materials
LDPE wrapper

2.13.2.5. Banana Fig

These are dried or dehydrated banana fruits with sticky consistency and sweet taste.

Ingredients: Ripe banana fruits, potassium metabisulphite

Process: Ripe banana fruits are peeled, treated with 1% potassium metabisulphite and dried either in sun or oven at 50^0 Celsius for 24 hours.

Fig 144: Banana Fig

Packing: Banana figs can be packed in polyethylene bags or other suitable containers to achieve shelf life of 3-4 months under ambient conditions.

Machineries
Electric tray dryer , wrapper packaging machine

Packaging Materials
Laminated PP

2.13.2.6. Banana Flour

Fig 145: Banana Flour

Ingredients: Mature banana fruits, potassium metabisulphite

Process: Mature green bananas with have high starch content is best suited for banana flour preparation. Green mature fruits are blanched, peeled, treated with 1% potassium metabisulphite and sliced. These slices are then dehydrated and powdered to get flour which can be stored up to 1 year. Banana flour can be used bread, cake, biscuit, baby food, health drink, chappati preparation.

Packing: Banana flour can be packed in polyethylene bags to achieve shelf life of 3-4 months under ambient conditions.

Machineries
Electric tray dryer, Mixter grinder for flour, Sealing Machine

Packaging Materials
Laminated PP packets

2.13.2.7. Banana Powder

Fig 146: Banana Powder

Ingredients: Ripe bananas

Process: Ripe bananas are used for powder preparation. The fruits are peeled, pulped, homogenized and spray dried at 30-32^{0}C and less than 30 % humidity. It can also be used using drum drier wit temperature not exceeding 94^0 C. Banana powder should have 2-4% moisture content. Banana powder can be used in confectionery industry, ice cream products and baby food preparation.

Machineries
Spray dryer/ Drum drier
Pulper

Packaging Materials
Laminated PP packets

2.13.2.8. Banana Jam

FSSAI Specification: Jam is a product obtained by cooking fruit pulp with sugar and acid to a desired consistency. Jam contains 0.5-0.6 percent acidity and 68% total soluble solids. FPO

specification for jam is (i) minimum per cent of total soluble solids in final product 68 and (ii) minimum per cent of fruit juice in final product should be 45.

Ingredients: Banana pulp 1 lt, sugar 800 gm, citric acid 6 g, sodium benzoate 1 g.

Process Flow

1. Ripe fruit
2. Washing
3. Peeling
4. Cutting/grating and pulping
5. Addition of Sugar and water
6. Cooking up to desired consistency
7. Addition of citric acid
8. Judging the end point by temperature (105°C) or TSS (68-70%)
9. Filling hot into clean and sterilized bottles
10. Cooling
11. Waxing
12. Capping
13. Storage in a cool and dry place

Fig 147: Banana Jam

Machineries and Packaging Materials

Machineries
Pulper for banana, Steam Jacketed Kettle, Electric boiler, Pasteurization and sterilization machines with automatic bottle filling for jam or jelly, Bottle Filling Machine, Lug Cap Sealing Machine, Brix meter

Packaging Materials
Glass jars, PP bottles

2.14. Strawberry

2.14.1. Introduction

Strawberry is an exotic fruit and grown in humid atmosphere and acidic soil. Most of the states in North East India are hilly, and have the prerequisite cultivation conditions for flourishing propagation of strawberry. The beautiful fruit can be made into various products as mentioned under.

Fig 148: Strawberry

2.14.2. Processing and Value Addition of Strawberry

2.14.2.1. Strawberry Jam

FSSAI Specification: Jam is a product obtained by cooking fruit pulp with sugar and acid to a desired consistency. Jam contains 0.5-0.6 percent acidity and 68% total soluble solids. Jam can be prepared from several fruits such as: Apple, Aonla, mango, Pear, Papaya, Strawberry, Goose berry, Strawberry. FPO specification for jam is (i) minimum per cent of total soluble solids in final product 68 and (ii) minimum per cent of fruit juice in final product should be 45.

Ingredients: Fruit pulp: 1 litre, Sugar: 800gm, Citric acid: 6g, Sodium benzoate: 1g

Process Flow

1. Ripe fruit
2. Washing and removal of leaves and stems (if any)
3. Blanching (dipping in boiling water for 5-7 minutes)
4. Pulping
5. Weighing and calculation of sugar and citric acid
6. Addition of Sugar to pulp and heating
7. Cooking up to desired consistency
8. Addition of citric acid
9. Judging the end point by temperature (105°C) or TSS (68-70%)
10. Filling hot into clean and sterilized bottles
11. Cooling
12. Waxing
13. Capping
14. Storage in a cool and dry place

Fig 149: Strawberry Jam

Machineries and Packaging Materials

Machineries
Pulper, Steam Jacketed Kettle, Electric boiler, Pasteurization and sterilization machines with automatic bottle filling for jam or jelly, Bottle Filling Machine, Lug Cap Sealing Machine, Brix meter

Packaging Materials
Glass bottles, Polypropylene pouches/bottles

2.14.2.2. Frozen Strawberry

Ingredients: Strawberry pieces, Sugar, Water, Ascorbic Acid: 5g/ kg sugar solution, Citric Acid: 3 g/ kg sugar solution

Process Flow

Fig 150: Frozen Strawberry

1. Firm ripe fruit/ matured vegetable
2. Washing
3. Trimming
4. Cutting into slices/ keeping whole
5. Blanching (dipping in boiling water for 5-7 minutes)
6. Covering with 40° B sugar syrup containing 0.3% citric and 0.5% ascorbic acid
7. Freezing at -40° C
8. Sealing of polythene bag
9. Placing in waxed cartons
10. Storing at -20° C

Machineries

Fruits and Vegetables Washer, Slicer, Filling Machine, Blancher, Deep Freezer

Packaging Materials

PE or PP Laminates

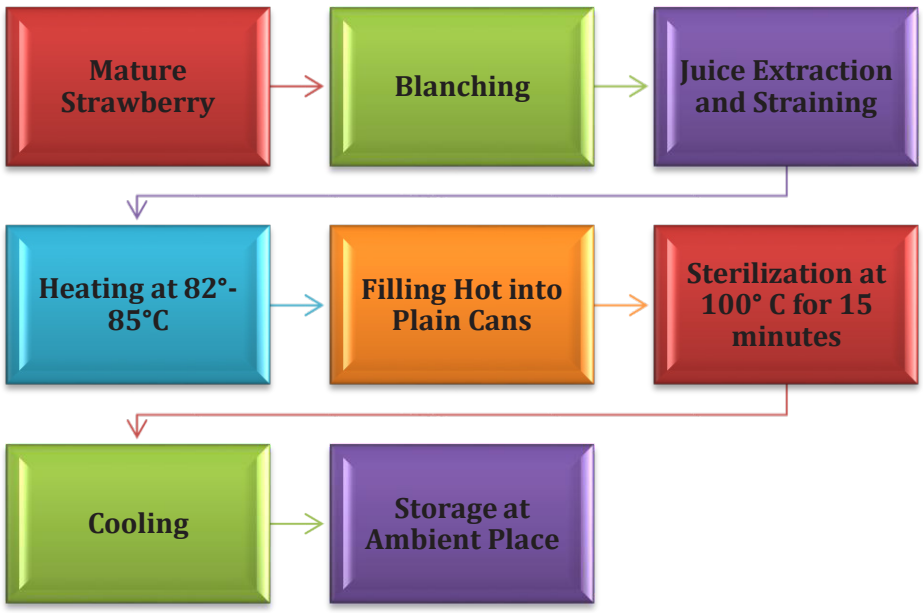
2.14.2.3. Strawberry Juice

Fig 151: Strawberry Juice

FSSAI Specification: Juice may be pure with natural sugar or sweetened, which has 10 per cent total soluble solids and 85% juice. FSSAI specifications for unsweetened juice are: (i) minimum per cent of total soluble in natural content, (ii) minimum percent of fruit juice 100 per cent. The permissible limit of preservative as sulphur dioxide/KMS 350 ppm. FSSAI specification for sweetened juice is: (i) minimum percent of total soluble solid is 10 and (ii) minimum per cent of fruit juice 85. The permissible limit of preservative as sulphur dioxide/KMS 350 ppm.

Ingredients: Ripe Strawberry, KMS

Process Flow



Machineries and Packaging Materials

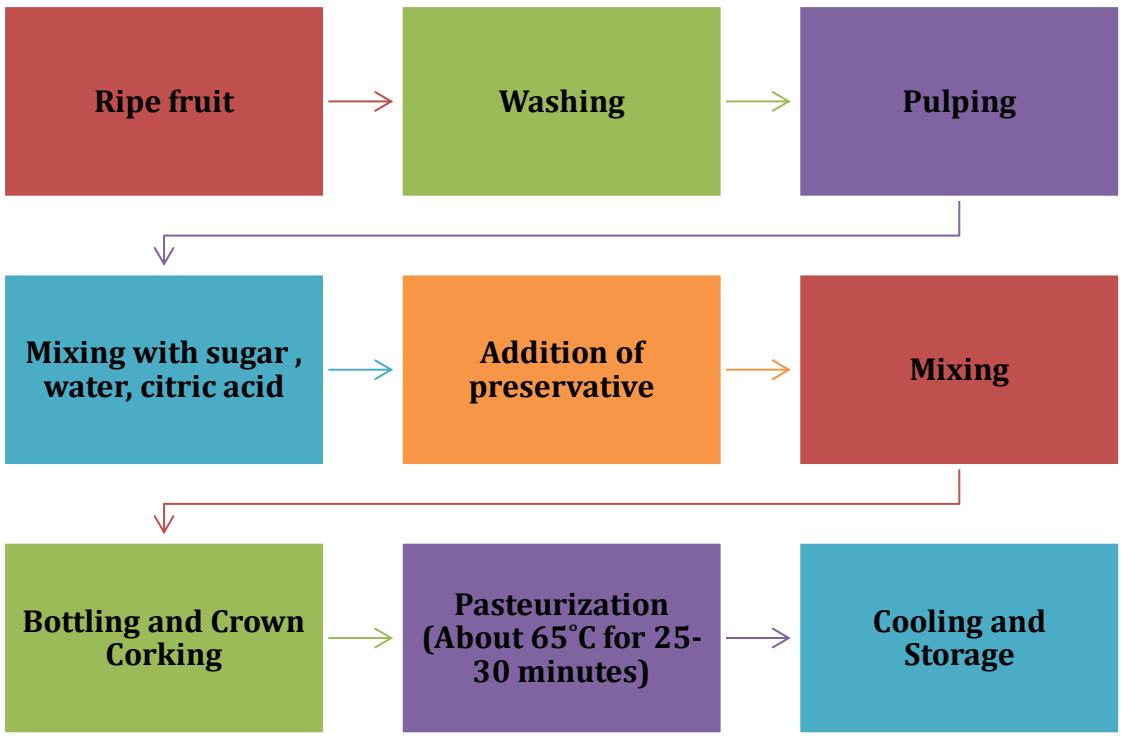
Machineries	Packaging Materials
Fruits and Vegetables Washer, Strawberry Peeler, Slicer, Fruit Crusher and Juice Extractor, Steam Jacketed Kettle, Boiler, Can Filler, Sterilizer/ Retort/ Autoclave, Cooling Chamber, Bottling Filling Machine, Crown Corking Machine, Labelling Unit, Cold Storage, Brix meter	Glass bottles, PET bottles, Polypropylene (PP) bottles, Tetrapack (for aseptic packaging), Laminated and Pouted Pouches

2.14.2.4. Strawberry Ready-To-Serve

FSSAI Specification: Ready-to-serve beverages are the most popular bottled products which contains at least 10% fruit juice and 10% total soluble solids. FSSAI specifications for ready-to-serve beverage are: (i) minimum percent of TSS 10 and (ii) minimum % of fruit juice 10 except lime juice (5%).The permissible limit of preservative as sulphur dioxide/KMS 70ppm and as benzoic acid/ sodium benzoate 120ppm. Acidity of the juice should be 0.3%.

Ingredients: For 1 kg of RTS, Extracted juice: 100 g (Min.), Sugar: 100 g, Citric Acid: 3 g, Water: 800 ml, KMS: 0.07 g or Sodium benzoate: 0.12 g.

Process Flow



Machineries and Packaging Materials

Machineries	Packaging Materials
Fruits and Vegetables Washer, Fruit Pulper with Strainer, Steam Jacketed Kettle, Boiler, Bottle Filling Machine, Crown Corking Machine, Brix meter, Cold Storage	PET bottle, Glass bottles, Tetrapack (for aseptic packaging), Laminated and Pouted Pouches, PP Bottles

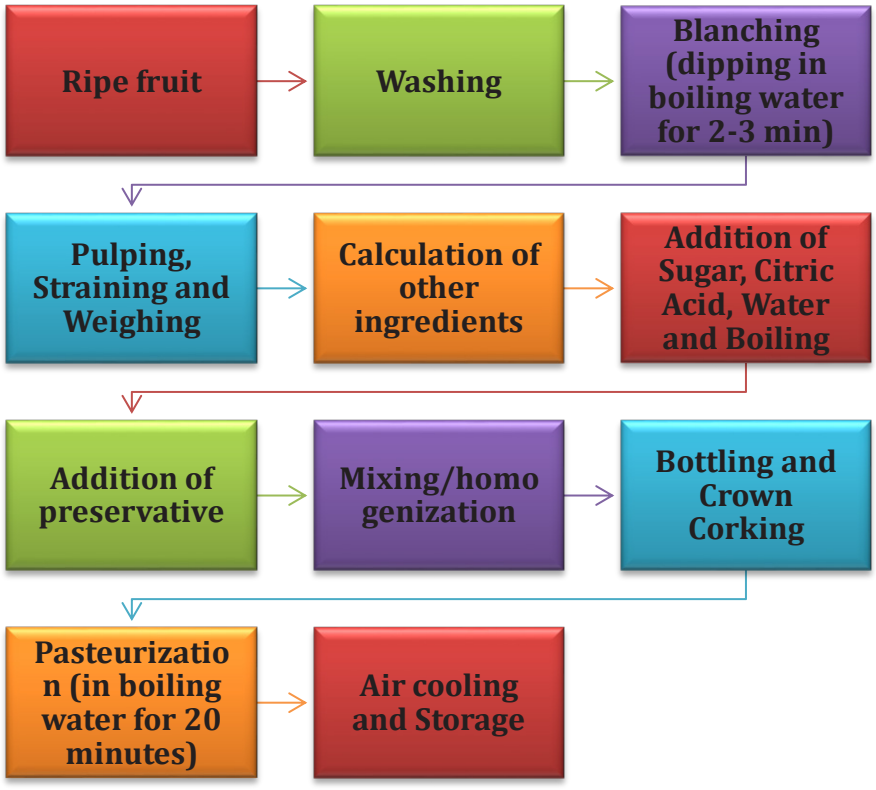
2.14.2.5. Strawberry Nectar

FSSAI Specification: This is a type of fruit beverage which contains at least 20% fruit pulp/juice and 15% TSS. Experiences however shown that nectar prepared with 15% sugar is very sweet. It has normally 0.3% acidity. Dilution is not required before serving.

The most suitable fruits for preparation of nectar are papaya, mango, peach, and apricot. FSSAI specifications for nectar are: (i) minimum percent of TSS 15 and (ii) minimum percent of fruit juice 20% except Strawberry and orange(40). The permissible limit of preservative as sulphur dioxide 70ppm and as benzoic acid 120ppm.

Ingredients: For 1 kg of Nectar, Extracted juice: 200 g (Min.), Sugar: 150 g, Citric Acid: 3 g, Water: 650 ml, KMS: 0.07 g or Sodium benzoate: 0.12 g.

Process Flow



Machineries and Packaging Materials

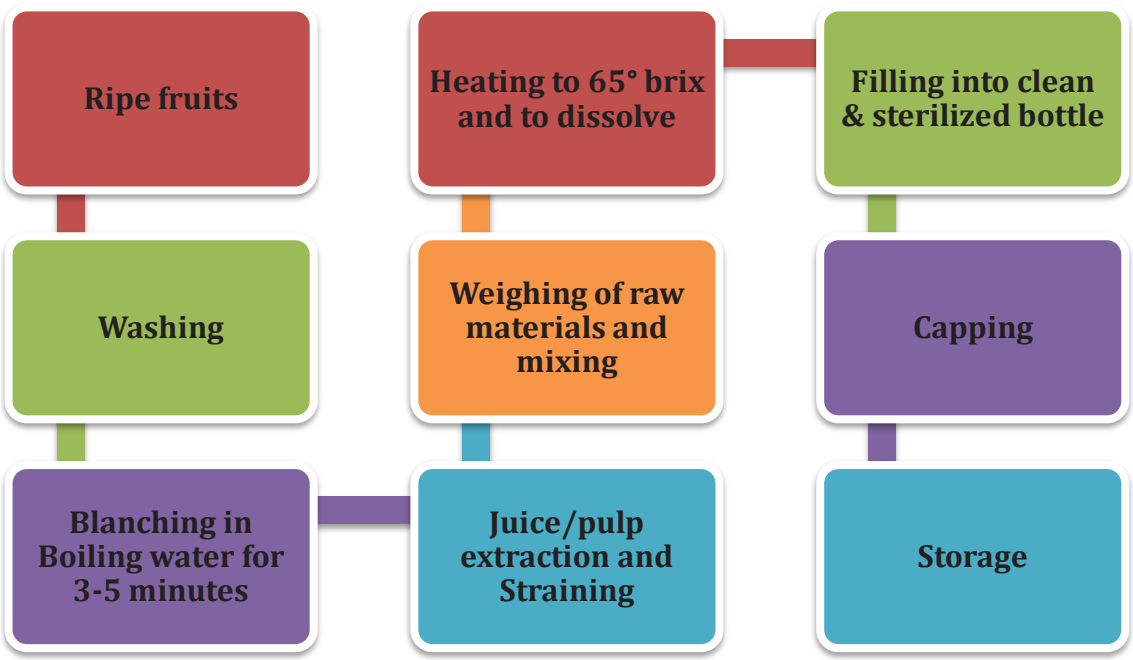
Machineries	Packaging Materials
Fruits and Vegetables Washer, Fruit Pulper with Strainer, Steam Jacketed Kettle, Boiler, Bottle Filling Machine, Crown Corking Machine, Brix meter, Cold Storage	PET bottle, Glass bottles, Tetrapack (for aseptic packaging), Laminated and Pouted Pouches, PP Bottles

2.14.2.6. Strawberry Syrup

FSSAI Specification: :A type of fruit beverage contains at least 25% fruit juice/pulp and 65% total soluble solids with about 1.3% acidity. FSSAI specifications for syrup are: (i) minimum percentage of total soluble solids 65 and (ii) minimum percentage of fruit juice 25. The permissible limit of the preservative as sulphur dioxide and benzoic acid are 350 ppm and 600 ppm respectively.

Ingredients: For 1 kg of Syrup, Extracted juice: 250 g (Min.), Sugar: 600 g, Citric Acid: 13 g, Water: 150 ml, KMS: 0.35 g or Sodium benzoate: 0.6 g.

Process Flow



Machineries and Packaging Materials

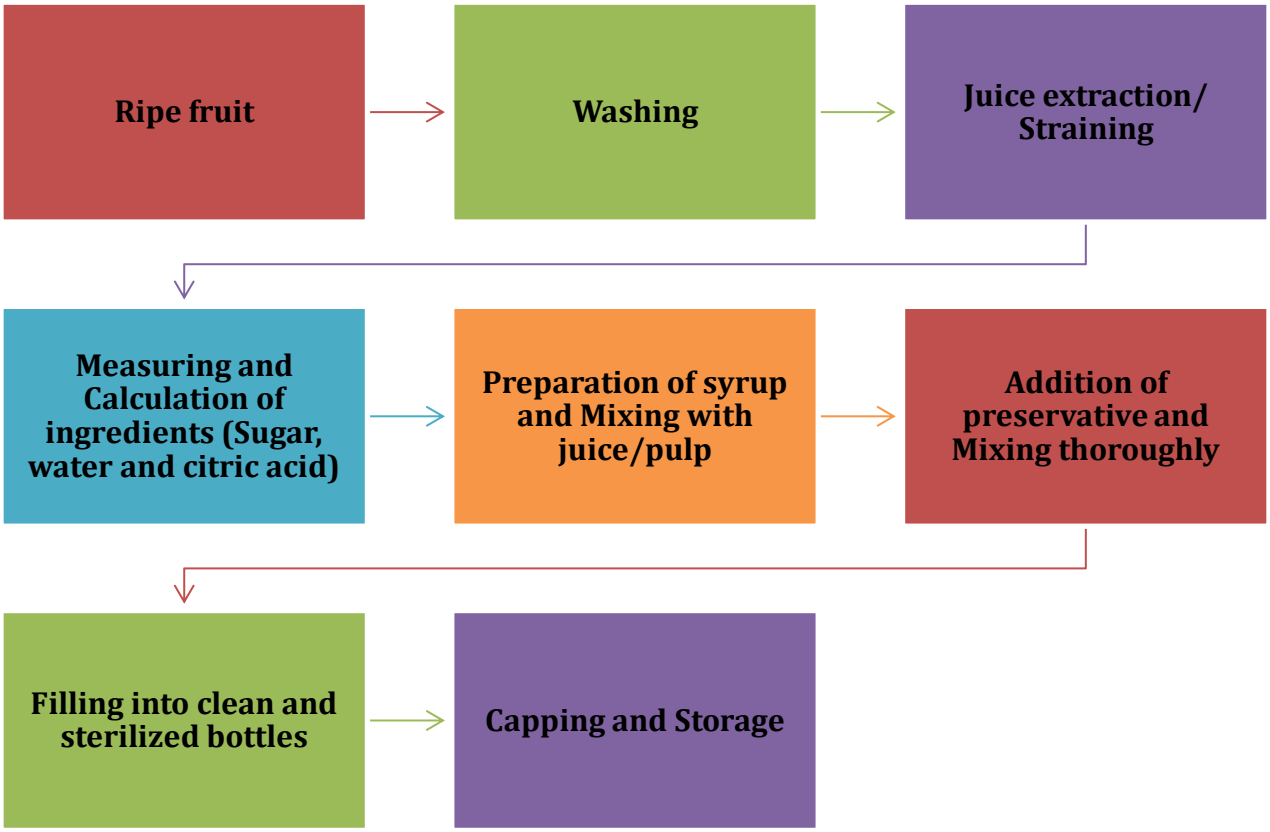
Machineries	Packaging Materials
Fruits and Vegetables Washer, Fruit Pulper or Juicer with Strainer, Steam Jacketed Kettle, Boiler, Bottle Filling Machine, Crown Corking Machine, Brix meter, Cold Storage	PET bottle, Glass bottles, PP Bottles

2.14.2.7. Strawberry Squash

FSSAI Specification: A type of fruit beverage which contain at least 25% percent juice and 40% total soluble solids. It also contains about 1% acidity and 350ppm sulphur dioxide and 600ppm sodium benzoate (in coloured juices). It is diluted before being served. FSSAI specifications for squash are: (i) minimum per cent of total soluble solids 40 and (ii) minimum per cent of fruit juice 25. The permissible limit of the preservative as sulphur dioxide 350 ppm or as benzoic acid 600 ppm.

Ingredients: For 1 kg of Squash, Extracted juice: 250 g (Min.), Sugar: 400 g, Citric Acid: 10 g, Water: 350 ml, KMS: 0.35 g or Sodium benzoate: 0.6 g.

Process Flow



Machineries and Packaging Materials

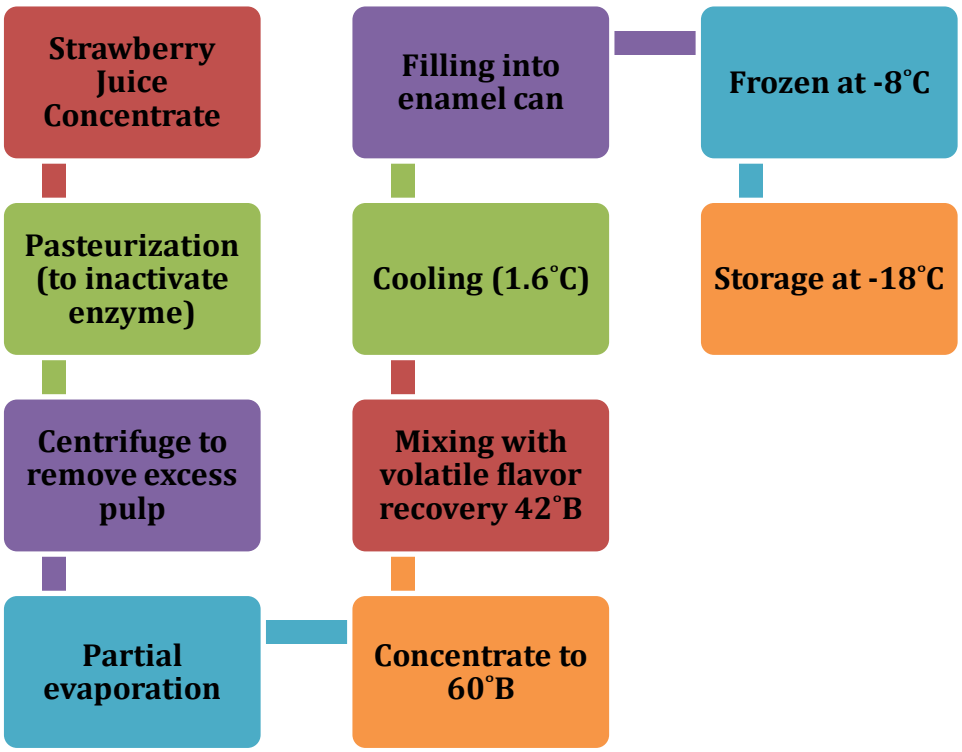
Machineries	Packaging Materials
Fruits and Vegetables Washer, Fruit Pulper or Juicer with Strainer, Steam Jacketed Kettle, Boiler, Bottle Filling Machine, Crown Corking Machine, Brix meter, Cold Storage	PET bottle, Glass bottles, PP Bottles

2.14.2.8. Strawberry Juice Concentrate

FSSAI Specification: This is a fruit juice, which are concentrated by removal of water either by heat or by freezing. Removal of water in order to concentrate the juice by heating is economically most favourable and widely used. Fruit juice concentrate contains at least 32% total soluble solids. Fruit juice concentrate is easier to handle during packaging, transport and storage due to reduced weight and bulk. Fruit juice concentrate can be used for preparation of various types of beverage including carbonated beverage. Fruit juice concentrate can be prepared from various fruits.FPO specifications for fruit juice concentrate are: (i) minimum percentage of total soluble solids 32 and (ii) minimum percentage of fruit juice 100. The permissible limit of the preservative as sulphur dioxide 1500 ppm.

Ingredients: Concentrated Fruit Juice (32% TSS), KMS: 1.5 g/ kg concentrate

Process Flow



Machineries and Packaging Materials

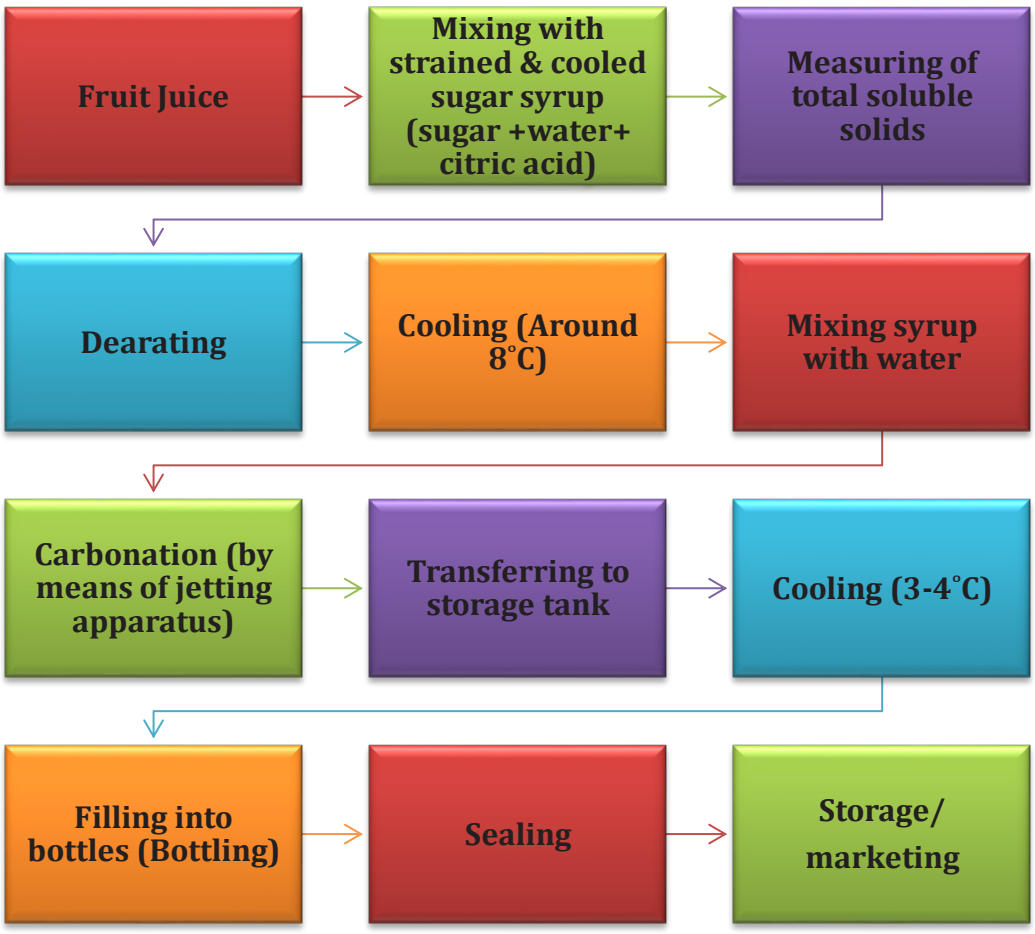
Machineries
Fruits and Vegetables Washer, Fruit Pulper or Juicer with Strainer, Steam Jacketed Kettle, Boiler, Pasteurizer, Centrifuge, Evaporator and Condenser, Can Filling Machine, Crown Corking Machine, Brix meter, Deep Freezer

Packaging Materials
Can, Glass bottles, PP Bottles

2.14.2.9. Strawberry Carbonated Beverage

Fruit based syrup such as Strawberry, orange, lime, grape and guava can be used for carbonated soft drink. Principally fruit juice based carbonated soft drink processing is a mixture procedure with fruit juice, sugar, water, acid and carbon dioxide. The secret of a recipe basis lies in harmonizing the raw materials in such a way that the finished product has refreshing stimulation character.

Process Flow



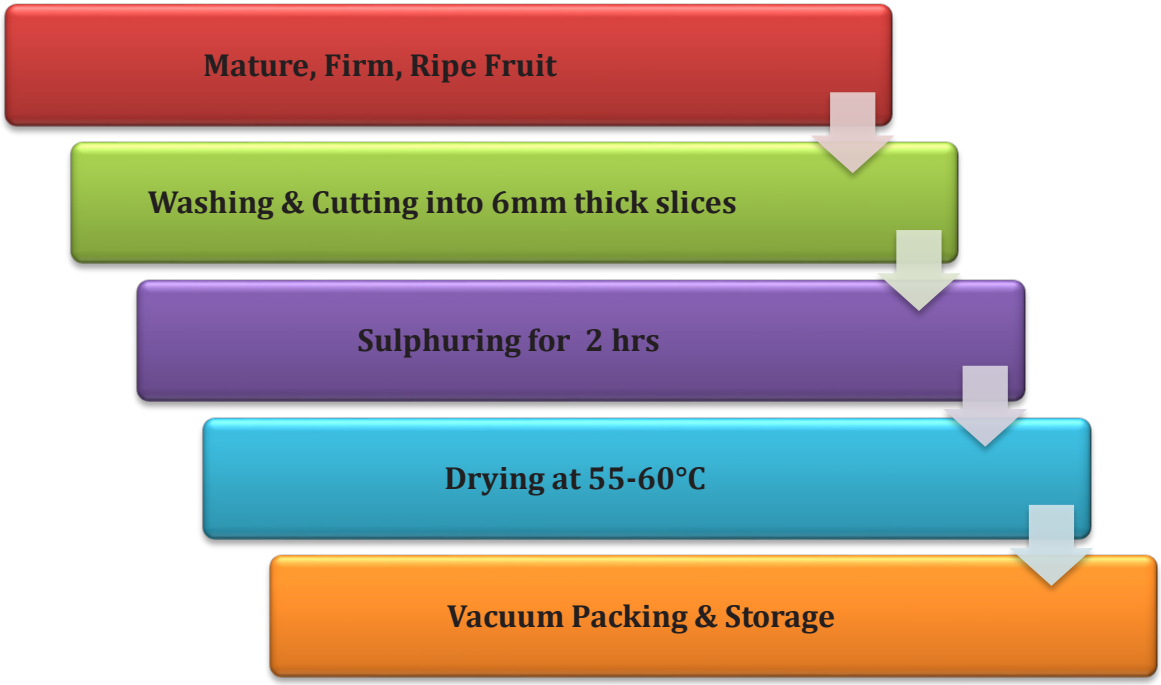
Machineries and Packaging Materials

Machineries	Packaging Materials
Fruits and Vegetables Washer, Fruit Pulper or Juicer with Strainer, Steam Jacketed Kettle, Boiler, Dearation Tank, Cooling Tank, Mixing Tank, Carbonation Unit, Bottle Filling Machine, Sealing Machine, Brix meter, Deep Freezer	Can, Glass bottles, PET bottles

2.14.2.10. Dehydrated Strawberry

Ingredients: Strawberry, Sulphur Gas

Process Flow



Machineries and Packaging Materials

Machineries	Packaging Materials
Fruits and Vegetables Washer, Sulphuring Gas Unit, Tray Dryer, Vacuum packaging Machine	LDPE Pouches, Laminates

Fig 152: Pulper

Fig 153: Steam Jacketed Kettle

Fig 154: Boiler

Fig 155: Pasteurizer

Fig 156: Vacuum Packaging Machine

Fig 157: Juice Extractor

Fig 158: Tray Dryer

Fig 159: Bottle Filling Machine

Fig 160: Deep Freezer

Fig 161: Brix Meter

Fig 162: Can Filling Machine

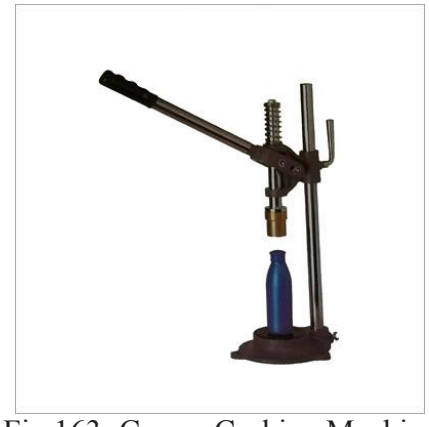


Fig 163: Crown Corking Machine

Fig 164: PET Bottles

Fig 165: Glass Bottles

Fig 166: Glass Jar

Fig 167: LDPE Packet

Fig 168: Laminated Poly Packet

Fig 169: Can

3. Challenges and Strategies for Sustainable Value Chain & Entrepreneurship

3.1. Challenges for Food Processing Sector in Meghalaya

Meghalaya like other states of NE is basically an agrarian economy where 80 per cent population depends on agriculture and allied activities for livelihoods. In spite of the contribution of agriculture to the total GDP being very low as compared to mining and tourism sectors, agriculture possess great importance in terms of livelihood and income generation for the majority of the population in this state. The favorable agro-climatic conditions and inherent organic cultivation practices of diverse high value agro-horticultural crops such as turmeric (lakadong), ginger, long pepper, black pepper, cinnamon, pineapple, strawberry provide ample opportunities for generating significant income and employment through sustainable value chain and entrepreneurship development in the state.

However, in spite of having potential for value chain development in food processing, there are many inherent constraints in the state that may act as impediments for sustainable development of agro-horticultural value chain. These constraints are not only state specific but also general in nature especially from NE and also from all India perspectives in few cases. Evolving successful value chain therefore requires a thorough understanding of these constraints to develop a comprehensive strategy at the planning and organizational stages. A detailed account for some of the significant constraints relevant to NE and especially Meghalaya are given below:

3.1.1. Production and Land Holding Pattern

In Meghalaya, the area under horticulture has increased at 2.59 per cent AAGR from 111.23 thousand ha in 2011-12 to 129.46 thousand ha in 2017-18 whereas the total horticultural production has increased at 5.75 per cent AAGR from 789.08 thousand MT in 2011-12 to 1091.99 thousand MT in 2017-18. Further, the production of fruit crops in Meghalaya has significantly increased from 300.42 thousand MT in 2011-12 to 443.02 thousand MT in 2017-18. In production of fruit crops Meghalaya recorded the highest AAGR of 6.71 per cent followed by Assam (4.99%) and Manipur (4.69%) during the period. Further, both in area and production of vegetables and spices Meghalaya recorded positive annual average growth rate (AAGR) during 2011-12 to 2017-18. However, about 80% of the farmers in the NE region belong to small (less than 1.44 ha) and marginal (less than 0.40 ha) land holding category and the same situation is found in Meghalaya. This clearly means that all this produces are scattered among large number of small and marginal farmers distributed across different locations of the state. Further, there is inadequate information on the available production of proceessable varieties under different crops. There are many wild varieties on which reliable statistics on production and area is

unavailable. Further, data on accurate production in different cluster segments under each important crop also seems to be inadequately available. And, most importantly, the productivity of different crops is very low due to inadequate technological adoption and farm mechanization. In general the mode of the farming community seems to be reluctant towards structural and technological changes in production. They are found to be satisfied with the level and scale of operation. In some cases the shifting cultivation "Jhum" is still prevalent. So, all these issues put together, it can be said that the biggest challenge for growth of food processing in Meghalaya is the production and availability of high value crops which at present needs much more efforts for augmentation.

Strategy: (i) Technological intervention for production augmentation of different high value agro-horticultural crops; (ii) proper inputs supply, disease and pest management; (iii) area expansion utilizing fallow land; (iv) farm mechanization; (v) extensive extension services across state; (vi) accurate assessment of production and availability of different varieties under different crops both at state level and cluster/supply chain routes; (vii) estimation of marketable surplus after raw consumption for each crops and varieties in different seasons are must. All these efforts will provide the solid basis for developing sustainable value chain.

3.1.2. Climate Stress

Climate change is one of the major challenges for mankind in this time. This is not only affecting the human beings but also has huge negative impact on the production and productivity of agriculture and allied sectors. Though, this is a global issue, it has definitely negative impact on states' productivity.

Strategy: (i) More in depth and thorough research on evolving strategies to tackle the negative impact of climate change on productivity of different crops across the state is needed; (ii) need for evolving climate resilient varieties, management practices and cropping system for agriculture in the state.

3.1.3. Aggregation and Backward Linkage

The scattered distribution of produces among large number of small and marginal farmers in the state puts huge challenge for aggregation and it leads to increase in logistics cost. This issue is common not only in different state of NE including Meghalaya, but also across in India. In India there have been many experiments on aggregation model such as SHG Group, SHGs Federation, Specialized Cooperatives, Farmers' Producer Organizations (company, society) etc in different states. Some of model/models were successful in some areas and some models did not give better results. In NE including Meghalaya also, efforts are on to develop FPOs/SHG Federations by different organizations in different clusters/ supply chain routes. But unfortunately, in most of the cases, these FPOs are either on paper or doing nothing significant in terms of production and

processing. The backward linkages of processors with these FPOs/producers are fragile in many cases because of running out of pre agreed commitment and price due to dynamic changes in markets and demand. The FPOs are not equipped with efficient managerial skills especially on finance and marketing management. Therefore, aggregation remains huge challenge for successful value chain development.

Strategy: (i) Formation of FPOs after accurately mapping the available bio resources under its' cluster; (ii) encourage each FPOs to concentrate on particular crop and variety to provide adequate quantity to the processors; (iii) imparting adequate managerial skills on finance and marketing to FPO management; (iv) augmentation of financial base of FPOs through equity capital and venture capital; (v) FPOs should have direct contact with processor without any middlemen to reduce the length of supply cahin; (vi) the contract farming has to be based on strong agreement on inputs supply, outputs supply and price realization, (vii) benefits of different central sponsored schemes in terms of grant and subsidy should be fully exploited by FPOs. All these efforts will definitely increase the farmer's share in ultimate consumer's rupee.

3.1.4. Demand, Market Linkage, Regulation and Logistics

The first question before entering into processing has to be like "Is there really any need for processing and is there really any demand in the market?". The proper assessment of demand for the value added products has to be assessed. In Meghalaya, there are some high value crops like turmeric, ginger, strawberry, pineapple etc. Presently, information to the local farmers on national market with high demand for these crops is inadequate. The entrepreneurs cannot process and add value to all its crops. The understanding on the type of value added products having high demand is less. The marketing channels at present available in the state are inefficient. Farmers' has less bargaining power because of individualistic nature of production in marginal land in fewer quantities. Prevalent of unorganized and unregulated market structure for primary agri-horticultural commodities in the state limits its linkage and integration with the distant markets. There are inefficient supply chains without improved logistics and with multiple players for all agri-horticultural produces. This not only limits the market outreach of the producers but also reduces the producers' share in ultimate consumers' rupee and thus further constraints the capacity of small holder producers in scalable commercial venture and market participation.

Strategy: (i) Development of organized and regulated market structure with efficient supply chain and logistics facilities connecting the production clusters of producers' groups at potential pockets is much needed (ii) identification of supply chains of high value horticultural products having huge demand in the distant domestic and international markets and proper identification and development of air evacuation points or railway evacuation points for each clusters; (iii) assessment of accurate marketable surplus of value added crops after local consumption; (iv) assessment of demand for different crops and its' value added products in different markets; (v)

linking local regulated markets with national market through innovative means like online platform; (vi) adopting innovative value addition and packaging for the high value crops and thus capturing niche markets or creating own demand; (vii) developing and strengthening brand value for exclusive and highly demanded crops/products and adopting innovative promotional activity; (viii) ultimately, all the supply chains for different crops must ensure adequate profit margin for the production clusters.

3.1.5. Technology, Innovation and Skill Up-gradation

Technological innovation and adoption in processing and other different segments of value chain is not up to the expected level. This situation is same across NE. Skill level of different stakeholders being it producers, processors and marketers involved in the supply and value chain are limited in the region and thus limits in getting comparative advantage in the competitive markets.

Strategy: (i) Adoption of innovation process and product technologies; (ii) more extension efforts in technology dissemination; (iii) intensive R&D based on local crops and problems; (iv) augmenting the skills of stakeholders on production, processing, marketing, finance etc through proper training.

3.1.6. Support Infrastructure

Presently, preprocessing infrastructure like, cold chain, warehouse, modern pack house, food testing laboratory etc are very limited in the state.

Strategy: (i) More cold chain, warehouse, modern pack house, food testing laboratory with optimum capacity based on proper estimation of primary output at each identified clusters has to be done.

3.1.7. Finance and Schemes

Access to finance especially by small and marginal producers are very limited in Meghalaya like other parts of NE and thus limits the production and commercialization of agri-horticultural enterprises. There are many central schemes available (as discussed earlier). However, the application from Meghalaya is insignificant or nil. In many cases, the feedback of the prospective entrepreneurs suggests that the central sector schemes are not suitable for NE and need modification. Most of the schemes have different structural components like grant plus loan plus promoters contribution. Entrepreneurs in many cases, expresses difficulty in availing loan components from bank and favour medium projects suitable for small and medium enterprises than projects in crores. Therefore, availability and accessibility of finance is a big issue for the resource poor farmers.

Strategy: (i) Extensive efforts are needed from financial institutions and government for increasing credit accessibility to the small holder farmers and entrepreneurs through different schemes; (ii) bringing more awareness and modification on the structural components and guidelines of the present central sector schemes to suite local needs; (iii) imparting managerial training especially on fund management for best utilization of finance and other related assets.

3.1.8. Total Quality Management

Poor quality has been one of the major issues for Indian producers and processors limiting their presence in the international market and there is no exception for the farmers of the region also. In this aspect though NE has some advantage because of by default organic agricultural practices; however, proper certification of primary inputs and ensuring total quality management in the entire supply chain is a huge challenge in the NE.

Strategy: (i) expediting organic, GI certification process; (ii) ensuring best practices during processing, handling, storage, transport and distribution; (iii) establishment of effective traceability model for each high value crops and products for assuring potential international markets; (iv) proper packaging and packing; (v) abiding quality specification norms for specific international markets; (vi) ensuring quality food testing infrastructure and services with adequate technology and scientific manpower.

3.1.9. International Trade and Competitiveness

Abolishing distorted trade practices are though standard recommendations for free and fair international trade, some degree of domestic protection and help for local resource poor small holder farmers and first generation entrepreneurs in agri-horticultural trade is must until they achieve a level playing field in international market.

Strategy: (i) Ensuring level playing field through transport, logistics and other industrial subsidies in the state by state and central govt. based on proper assessment.

3.1.10. Basic Infrastructure and Utilities

Remote geographical location and lack of basic infrastructure like roadways, air transportation, energy problems etc are major issues in NE including Meghalaya. Since independence, it has been one of the major constraints obstructing industrialization and economic participation at the national and international level. Development of sustainable agro-horticultural value chain in Meghalaya is also facing the same problems of basic infrastructure and logistic availability.

Strategy: (i) Efforts are needed to improve railway, air connectivity and accessibility of Meghalaya with other parts of India; and (ii) augmentation of energy and other basic utility at cheaper rate is must of agro-horticultural value chain to flourish in Meghalaya.

4. List of Abbreviation

AAGR	Average Annual Growth Rate
FPO	Farmer Producer Organization/Food Product Order
FSSAI	Food Safety and Standards Authority of India
GI	Geographical Indication
GDP	Gross Domestic Product
HDPE	High-density Polyethylene
KMS	Potassium Meta Bisulphate
LDPE	Low-density Polyethylene
MT	Metric Ton
NE	North East
PP	Polypropylene
PE	Polyethylene
PET	Polyethylene Terephthalate
ppm	parts per million
RTS	Teady-To-Serve
RH	Relative Humidity
SHG	Self Help Group
TSS	Total Soluble Solids
UV	Ultraviolet

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