



GUAR

STATUS, POTENTIAL, PROSPECTS, CHALLENGES AND R&D ROAD MAP

TOWARDS BOOSTING EXPORTS





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Executive Summary

Government of India during 2012-13, had constituted an Inter Ministerial Group (IMG) for addressing comprehensively the challenges of export oriented MSME Sectors including falling exports. As a follow up to the recommendations, Technology Information, Forecasting and Assessment Council (TIFAC), an autonomous body of Department of Science and Technology, was entrusted with the task of coordinating, nucleating and facilitating follow up actions towards infusion of appropriate new technologies for boosting of exports. In subsequent consultations with office of the Secretary Ministry of Commerce, Department of Expenditure, Ministry of Finance and Ministry of MSME, it was decided to initially prioritize two or three sectors for intervention and begin with initial assessment of the sectors. The basis of selection of sectors was: potential for higher technology inputs, higher value realization, future potential and sector performance. Guar Gum was one of the sectors taken up.

Guar or clusterbean is extremely drought hardy, deep rooted summer annual legume and has great economic and adaptive significance. Though originally grown for grain, vegetable, fodder, cattle feed, guar has attracted attention during the last few years due to shooting demands of guar gum - a product, in the shale oil and gas sector. Of the total global production of more than 15-20 lakh tones annually, India is the most important guar producer in the world contributing almost 75%-82% global guar grain production, followed by Pakistan (15%). Annually almost 75%-80% of guar gum including its few derivatives like refined splits, gum powder and guar meals are exported from India. However, in recent years, Indian exports have shown high volatility in both volume and value. Exports from almost 4.04 lakh ton worth Rs. 2811.93 crore during 2010-11, rose dramatically to almost 7.07 lakh ton in 2011-12, worth Rs. 16523.87 crore. In 2012-13, it dipped to 4.06 lakh ton worth Rs. 21287 crores, eventually picking up again in the year 2013-14, to almost 6.02 lakh ton worth Rs. 11734.5 crores.

In order to prepare a status report of the sector, prioritize requisite R&D and prepare an action plan towards boosting exports, TIFAC organized interactions with the different major sectoral stakeholders including Institutions like Central Arid Zone Research Institute (CAZRI), Jodhpur, Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar, National Institute of Agricultural Marketing (NIAM), Jaipur; Directorate of Soyabean Research, Indore; ONGC, WSS, Ahmadabad; Forest Research Institute, Dehradun; Indian Institute of Chemical Technology (IICT), Hyderabad and representatives of Guar Gum Manufacturers Association, Jodhpur, exporters, besides officials of Ministry of Commerce. The interactions were carried forward in a Brainstorming Workshop at Jodhpur on 29th May 2014 and it culminated in a meeting in a TIFAC on 11th September, wherein representatives of all the above organizations participated. This report is an outcome of the deliberations and subsequent feedback received.

The report has brought out the status, potential, and prospects of guar and its products. In view of the emerging and fast changing market scenario, the report highlights the challenges especially the technical ones, which needs to be addressed in a composite manner, so that our country is able to consolidate and expand our presence and reach in the market. Finally the report presents an action plan and strategy, both in the short and long term to tap the market potential to the maximum extent - both present and emerging.

The recommendations are categorized in two distinct categories: dissemination of best practices and trajectory of R&D efforts. The dissemination of best practices include recommended specific varieties of seeds for sowing and sowing methods in areas of differing rainfall - low, moderate and higher. The R&D Efforts recommended include needful breeding of seeds, introducing appropriate machinery for advanced processing, high Value Guar derivitization, developing alternate applications of guar etc.

The report also identifies specific domain and sectoral organizations for addressing respective R&D areas in the road map besides providing inputs for requisite policy formulation.





1.0 INTRODUCTION: GUAR

Guar or clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.], internationally known as guar, is an extremely drought hardy, deep rooted, summer annual legume of great economic and adaptive significance (Fig. 1).

Virtues of guar effectively match with low and erratic rainfall pattern and high ambient temperature habitats of arid regions. The crop may thrive very well in rainfall range of 250 mm - 450 mm with 3-4 spells, temperature range of 25 C - 40 C, Relative Humidity (RH) values of 50% - 65%, longer and warmer days with 8-9 hours sun shine, particularly at maturity. Guar is suitable for light to medium textured soils, with no water logging. The crop requires less input and restricted after care, matching with the arid farmers' livelihood conditions. Guar is grown for grain, vegetable, fodder, cattle feed and green manure purposes, mainly in rain fed habitats of Rajasthan, Haryana, Gujarat and to some extent in Punjab and Madhya Pradesh also. This crop has recently been introduced in non-traditional regions of Anantapur, Kadappa, Karnool and Chittoor (dry region of Andhra Pradesh). During summer season of 2012, guar had been successfully cultivated with 4-5 irrigations in parts of Chattisgarh and Vidarbha and in non-traditional summer seasons of Rajasthan and elsewhere. The cultivation in non-traditional regions and seasons has increased possibility of two crops in rainy and summer

Figure 1: Guar Plant



seasons. Even though, guar is cultivated on marginal lands with marginal inputs in these regions, yet it has occupied the status of export oriented cash crop. This is due to the presence of natural Polysaccharide Galactomannan gum content in seed endosperm. The gum content in guar seed has wide industrial uses. Almost 80%-85% guar gum produced in India is exported to other countries and rest is used for domestic commercial demand. Of late, increasing demands of guar gum from USA alone (to the tune of 7.0 lakh ton, in 2011-2012 has placed this crop in a prominent position. Thus leading to great economic benefits of Rs. 1.0 to 1.5 lakh/ha in 90-100 days only (particularly, in 2011-2013). Hence, guar is now considered as a source for providing livelihood security to arid zone farmers.

1.1 Production Scenario

Assessment over long term basis indicates that total global production of guar, in general, is realized to the tune of more than 12-15 lakh tones annually. However, India is the most important guar producer in the world and contributes almost 75%-82% global guar grain production, followed by Pakistan (15%), USA, South Africa, Sudan and Australia. In Pakistan, guar is mainly grown in Punjab and Sindh provinces contributing to almost 80% of total guar production in Pakistan under irrigated conditions.

The trends in area, production and productivity have greatly fluctuated over the years in India and particularly in Rajasthan region. Rajasthan decides the Guar production trends at the country level (Table 1). Over 10 year basis from 2000-01 to 2009-10, it may be seen that 2003-04 had witnessed maximum productivity (530 kg / ha) in India. It was followed by 2007-08. Average productivity of guar in India greatly fluctuates due to rainfall pattern in Western districts of Rajasthan. For instance, during severe drought year of 2002-03, the production sharply dropped to less than 2.0 lakh tones, whereas the same dramatically climbed to 15.0 lakh tones during 2003-04, probably due to high price of guar during previous year and increased area under cultivation during 2003-04.

Rajasthan alone grows country's 70%-75% guar and produces country's 60%-62% guar grains. The contributions from other states are: Haryana 22%, Gujarat 12% and Punjab 2.0% towards total guar area in India. In Rajasthan, six districts (Bikaner, Churu, Barmer, Jaisalmer, Hanumangarh and Jodhpur) occupy 60% of State's guar area. Punjab and Uttar Pradesh contribute only marginally. As per 2007-08 figures, there was mismatch between area



and production of guar at the districts level in Rajasthan. For instance, maximum area was occupied by Bikaner (23.0%) but maximum production (28.0%) was realized from the Hanumangarh district.

In Gujarat, drought prone districts viz, Kachh and Banaskantha are quite important from guar perspective. These districts occupy almost 41.7% of area under guar of the entire state. More important is the fact that productivity levels of guar in Kachh (610 kg/ha) and Banaskantha (604 kg/ha) districts are higher than the productivity of the state and the country as well.

TABLE 1: Area under guar cultivation, production and productivity of guar in India

Year	Area under cultivation (in thousand ha)	Production (in thousand ton)	Yield (kg/ha)
2000-01	3497	659	188
2001-02	2903	1090	375
2002-03	975	199	204
2003-04	2854	1513	530
2004-05	2867	903	315
2005-06	2956	1059	358
2006-07	3344	1169	350
2007-08	3472	1789	515
2008-09	3863	1936	501
2009-10	2996	595	199
2010-11	3382	1965	581
2011-12	3444	2218	644
2012-13	5152	2461	478
2013-14#	5603	2715	485
2014-15*	4255	2415	567

Source: Kumar and Solanki, 2012 and NCDEX, 2013

The figures also indicates that in recent years from 2010-11 onwards, there has been an increase in area under cultivation and production in India. However, productivity levels have not changed significantly, ranging from 478 kg/ha (2012-13) to 644 kg / ha (2011-12). It was probably due to sudden increase in demand for guar gum from USA (oil fields) and consequently the prices have also increased.

1.2 Yield Variation in Different States:

Yield variations in different states are generally the cause of worry for rain-fed crops, the same is also true for guar. In general, variation in production, when compared between different states and states vs country, appears due to variation in area and productivity (Table 2). For instance, in general, in Haryana 4.5 lakh ton guar is produced from 4.0 lakh ha area, whereas, from the state of Rajasthan only 8-10 lakh ton guar is produced from large area (28-30 lakh ha). Gujarat is producing 1.29 lakh ton guar from 1.95 lakh ha area. The obvious reason is that productivity of Haryana is

TABLE 2: Area under cultivation, production and productivity of guar in three main states (2008-09)

India/ State	Area (lakh ha)	Production (lakh ton)	Productivity (kg/ha)
India	33.00	12.50	490
Rajasthan	28.08	6.58	370
Haryana	4.00	4.50	1220*
Gujarat	1.95	1.29	669

Source: Kumar and Solanki, 2012

* Increased 206% during past 4 year

very high i.e. 1200 kg/ha which has increased to almost 206% in the past 5 years. The productivity of Punjab is also high (669 kg/ha). On the contrary, productivity of Rajasthan is only 370 kg/ha which is even lesser than national productivity. Critical analysis of productivity of major districts of Rajasthan reveals that productivity of Hanumangarh and Sriganganagar is very high (870 and 807 kg/ha, respectively). Productivity is quite low in Jodhpur, Churu and Barmer districts (144, 193 and 207 kg/ha, respectively). Thus, Barmer and Churu districts having large cultivating area (3.54 and 3.47 lakh ha, respectively), need attention towards increasing productivity to bring parity with dry district of Bikaner (415 kg/ha). Similarly, attempts in Jodhpur district need to concentrate on increasing cultivation area and productivity as well (Table 3).

Results from around 333 Front Line Demonstrations (FLDs) conducted during 2002-2006 in six (6) states of Rajasthan, Gujarat, Haryana, U.P., A. P. and Punjab, highlighted that grain yields of promising varieties were to the tune of 1243.5 kg/ha against 978.5 kg/ha, showing increase by 27.08% over local variety. However, potential yield of guar is estimated to the extent of 2000 to 2200 kg/ha indicating large gaps in yield levels. Hence, reflecting large gaps in realized and realizable grain yields of guar in rain fed conditions.

TABLE 3: Area under cultivation, production and productivity of guar in major districts in Rajasthan during 2008-09

India/ State	Area (lakh ha)	Production (lakh ton)	Productivity (kg/ha)
Bikaner	6.05	2.510	415
Barmer	3.54	0.734	207
Churu	3.47	0.670	193
Hanumangarh	3.19	2.270	870
Sriganganagar	1.80	1.450	807
Jodhpur	1.49	0.215	144
Nagaur	1.29	0.618	541

Source: Kumar D (2009)



2.0 GUAR PRODUCTS & BY-PRODUCTS - PRESENT SCENARIO, EMERGING ISSUES & CONSTRAINTS

2.1 Products & By Products

a) Guar Gum

Guar seed consists of three parts namely: (a) Hull - which is the outer layer / seed coat and constitutes around 15 - 17% by volume; (b) Germ Cell / embryo the inner soft mass constituting around 35 - 42 % of the volume and (c) Endosperm - constituting around 43 - 47 % of the seed by volume. Endosperm is the source of guar split and guar gum powder (Fig. 2).

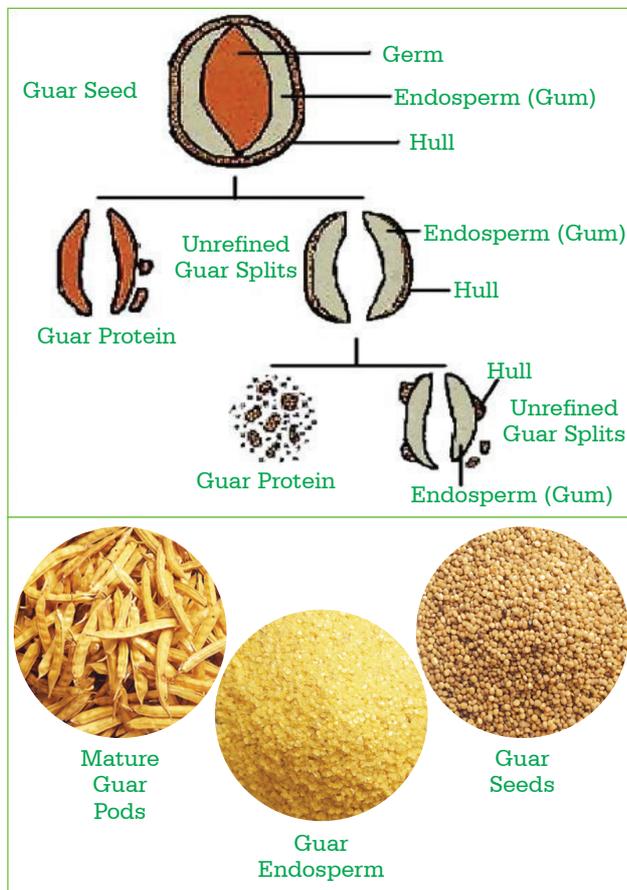


Figure 2: Typical Guar Seed Composition

Figure 3: Mature Guar Pods, Guar Seeds and Guar Endosperm

Figure 4&5: Guar Split and Guar Powder

Guar gum is a hydrocolloid polymer- cold water soluble polysaccharide. Its ability to hydrate without heating makes it very useful for many industrial applications. Further, its ability to form highly viscous colloidal dispersion at lower concentrations without heating makes it very useful for industrial uses. Solution with different gum concentrations can be used as emulsifiers and stabilizers because they prevent oil droplets from coalescing. Guar gum is also used as suspension stabilizer and is an economical thickener and stabilizer. Being non-ionic, it is not affected by ionic strength or pH but shows degradation at low pH and high temperatures (3 at 50 C, respectively). Guar gum retards ice crystal growth, non-specifically by slowing mass transfer across solid/liquid interface. The various derivatives or industrial grades of guar gum are manufactured by reaction of three hydroxyl groups with chemicals. The endosperm of guar seed (Fig. 3) is first converted into guar splits and then chemically processed and pulverized into guar powder (Fig. 4 and 5). There are two types of guar gum powder:

- (i) **Food grade guar gum powder:** Used in industries like food, cosmetics, pharma, personal care etc.
- (ii) **Industrial grade gum powder:** Used mainly in industries like paper, mining, explosive, fire fighting, oil drilling etc.

Guar Gum Quality

Guar gum quality can be assessed in terms of certain traits like, physical characteristics, powder grade as a thickening agent and guar gum powder standards as below:

- ❑ Guar gum is a white to yellowish white powder and is nearly odorless. Fine finished guar gum powder is available in different viscosities and granulometries depending on the desired level of viscosity and applications.
- ❑ It is a naturally occurring high molecular weight hydrocolloidal polysaccharide composed of galactan and mannan units combined through glycosidic linkages, which may be chemically described as galactomannans (Fig. 6).
- ❑ It is a cold water soluble polysaccharide consisting of mannose and galactose units.
- ❑ When dissolved in cold and hot water, guar gum forms a film of high viscosity which is a function of temperature, time and concentration.
- ❑ Solutions with different gum concentrations can be used as emulsifiers and stabilizers because it prevents oil droplets from coalescing; it is also used as suspension stabilizer.

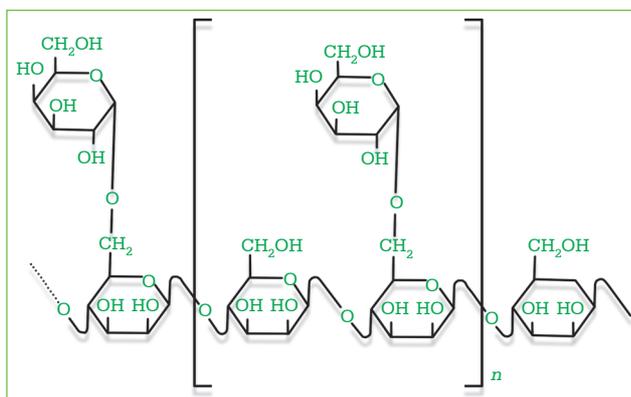


Figure 6: Chemical Structure of Guar Gum

Main chain of guar gum is made up of mannose units while side chain is made up of galactose units.

Guar Gum Powder Grades: Grades depend on industrial uses i.e. thickening, stabilizing, texturing, enhancing suspension and flow control properties; for industrial products, food products and / or for processing purposes. Grade Specifications

- (i) Food grade guar gum powder: For use in food, pharmacy, cosmetics related industries etc.

TABLE 4: Specification of Food Grade Guar Powder w.r.t to size & viscosity

Particle Size (MESH)	Viscosity Range (Cps)
200 - 200 (90 % Min.)	2000 - 7500
300 - 200 (99 % Min.)	3500 - 5000

- (ii) Industrial grade guar gum Powder: For use in industries like, paper, mining, explosive, oil-drilling etc.

TABLE 5: Specification of Industrial Grade Guar Powder w.r.t to size & viscosity

Particle Size (MESH)	Viscosity Range (Cps)
100 -100 (80 % Min.)	3000 - 6000

The particular grade of guar gum powder generally depends on following parameters (Source: Rodge, 2008):

- ❑ Active matter content
- ❑ Granulation,
- ❑ Viscosity,
- ❑ Power of Hydrogen (pH), and
- ❑ Degree of substitution

Commercial Export nomenclatures of Guar Gum are as under:

TABLE 6: Commercial Nomenclature of Guar Gum Powder

HS Code	130 232 30
CAS Number	9000 30-0
EEC Number	E - 412
BT Number	1302 3290
EINECS Number	232-536-8
IMCO Code	Harmless

Characteristics: Good quality guar gum have been defined in United States FCC and by European Union as below (Rodge, 2008)

TABLE 7: Characteristics of good quality guar gum

Sl.No.	Particular	Value
1.	Moisture content	14.0 %
2.	Acid Insoluble residue	4.0 5
3.	Galactomannan	75 %
4.	Protein content	7.0 %
5.	Arsenic content	3 ppm
6.	Lead	10.0 ppm
7.	Zinc	25 ppm
8.	Copper and Zinc	50 ppm

Uses

Guar gum is used in almost all systems where water is an impact factor. A number of food stuffs and product compositions require the use of colloids to modify the behavior of water in reference to other components. Guar gum is known to act as a stabilizer, binder, thickener, water proofing agent in various food products. With the dramatic increase of consumption of guar gum in oil and shale gas sector in recent years, the sector wise application as of now are food industries almost 25%, petroleum and mining industries around 60% and textile and cosmetics industries almost 15%. The indicated uses of guar gum have been tabulated below (Table 8).

Export of Guar Gum

Annually almost 75%-80% of guar gum including its few products and derivatives is exported from India. The major export derivatives of guar seed include refined splits, gum powder and guar meals. India exported 2.58 lakh ton of guar products (guar meal, guar gum refined split & guar treated and pulverized) worth Rs. 13.80 crores during 2008-09. This had increased to almost 4.04 lakh ton worth Rs. 2811.93 crore during the year 2010-11 (Table 9). It however, dramatically increased to almost 7.07 lakh ton in 2011-12, worth Rs. 16523.87 crore.



TABLE 8: Industrial uses of guar gum and expected functions

Sl.No.	Industry	Uses	Expected functions
1.	Textile printing	Cotton, rayon silk, wool sizing, carpet printing	Reduces wrap breakage & dusting film, formatting thickening for dyeing
2.	Paper	Wrapping paper, craft, photographic paper, filter	Replaces hemi-cellulose, increases strength, fold, pick, pulp hydration
3.	Oil well drilling	Drilling fluids hydraulic fracturing	Control of water loss, viscosity, suspension, turbulence, mobility, friction reduction
4.	Explosives	Stick explosives, blasting slurries	Water proofing, gelling agent
5.	Fire fighting	Water for fighting fire	Friction reduction, dispersion and direction control
6.	Coal mining	Coal suspension, stock	Friction reducing suspending agent
7.	Tobacco	Reconstitution of fragmental tobacco	Binding and strengthening agent
8.	Water treatment	Industrial and drinking water	Coagulant aid (food approved)
9.	Photography	Emulsions, gelatin solutions	Gelling hardening agent
10.	Pharmaceuticals	Medicines Diabetic treatment Laxative slimming aids Gastric hyper acidity Vitamin formation	Cholesterol treatment appetite depressant Reduction of urinary glucose loss Appetite depressant Stable water suspension
11.	Cosmetic uses	Hair shampoos Hair coordinators Lotions Ointments Tablets	Detergent, compatible thickener Protective colloid film forming agent Lubricating suspending agent Thickening agent giving unctuousness Granulating agent
12.	Bakery	Bread, cake, pastry, icing	ugh improvement, moisture retention, prolonged self life
13.	Frozen foods	Ice-creams, soft serves, frozen cakes	Water retention, ice crystal inhibitor and stabilizer
14.	Dairy products	Yoghurts, molasses, desserts	Inhibits when separates keeps texture after sterilization
15.	Processed cheese	Cottage cheese, cream, cheese	Increase the yield of curd solids, improves tenderness
16.	Instant mixes	Pudding sauces desserts, beverages	Fast, cold dispersible, thickening and text rising agent
17.	Canned foods	Pet foods, conned meal baby foods	Acid resistant, thickening and suspending agent
18.	Dressing and sauces	Salad ,cream, pickles	Fast, cold dispersible thickening and text rising agent
19.	Beverages	Coca drinks, fruit nectars, sugarless beverages	Acid resistant thickening and suspending agent

Source: D. Kumar, 2010



INDUSTRIAL APPLICATION OF GUAR & ITS DERIVATIVES



Figure 7: Few industrial applications of guar gum and its derivatives



Such steep rise in exports of guar gum was due to increase in demand of guar gum from USA primarily in drilling requirements of petroleum and shale gas. The exports of guar gum from India dipped to 4.06 lakh ton worth Rs. 21287 crores during 2012-13. In the year 2013-14, the export of guar gum again picked up to almost 6.02 lakh ton worth Rs. 11734.5 crores. It may be seen that though the exports of guar gum increased by almost 1.96 lakh ton in 2013-14 from the previous year, the value of exports is much lower. This has mainly been attributed because of the lower export price of guar gum per ton in 2013-14 then in 2012-13.

The following table and figures show the export status of aggregate guar gum exports and commodity wise exports of guar products from the year 2010-11 to 2013-14.

TABLE 9: Export Statement of Guar Gum from India including Guar Meal, Guar Gum Refined Split & Guar treated and pulverized

Commodity Code: 13023210, 13023220 & 13023230		
Year	Quantity (Lakh Ton)	Value (Rs. Cr.)
2010-11	4.039	2811.93
2011-12	7.073	16523.87
2012-13	4.063	21287.01
2013-14	6.019	11784.53

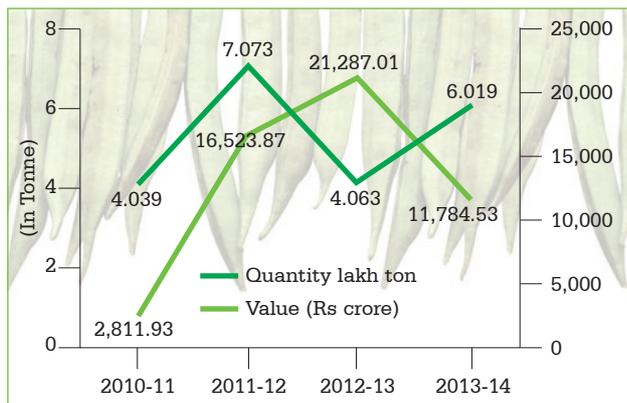


Figure 8: Export Statement of Guar Gum from India including Guar Meal, Guar Gum Refined Split & Guar treated and pulverized

Volume Growth: + 75.09 % (2011-12 on 2010-2011)
 - 42.56% (2012-13 on 2011-12)
 + 48.15 % (2013-14 on 2012-13)

Value Growth: + 487.63 % (2011-12 on 2010-2011)
 + 28.83 % (2012-13 on 2011-12)
 - 44.87% (2013-14 on 2012-13)

(Data source: SHEFEXIL, August, 2014)

Commodity Wise Guar Exports:

Guar Meal

TABLE 10: Export Statement of Guar Meal from India

Commodity Code: 13023210		
Year	Quantity (Lakh Ton)	Value (Rs. Cr.)
2010-11	0.3899	63.08
2011-12	0.8015	116.83
2012-13	0.7481	140.28
2013-14	1.321	289.07

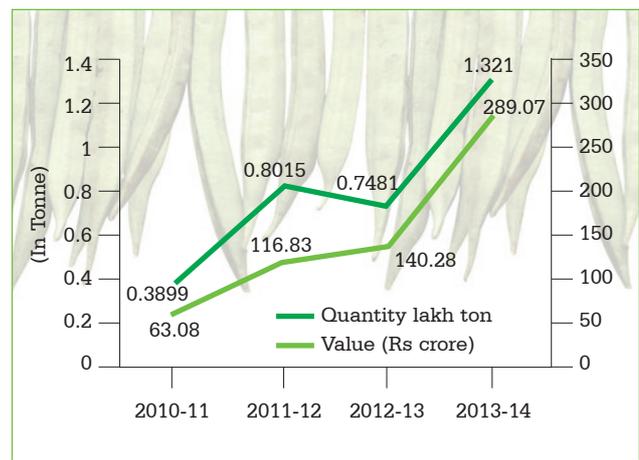


Figure 9: Export Statement of Guar Meal from India

Guar Refined Split:

TABLE 11: Export Statement of Guar Gum Refined Split from India

Commodity Code: 13023220		
Year	Quantity (Lakh Ton)	Value (Rs. Cr.)
2010-11	0.785	477.06
2011-12	1.024	1923.3
2012-13	0.705	3390.54
2013-14	0.827	1484.09

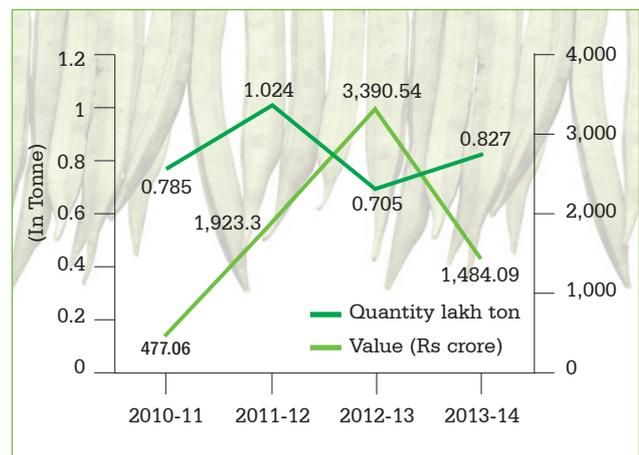


Figure 10: Export Statement of Guar Gum Refined Split from India



Guar Treated and Pulverized:

TABLE 12: Export Statement of Guar Gum Treated and Pulverized from India

Commodity Code: 13023230

Year	Quantity (Lakh Ton)	Value (Rs. Cr.)
2010-11	2.865	2271.79
2011-12	5.247	14483.74
2012-13	2.6098	17756.19
2013-14	3.871	9961.37

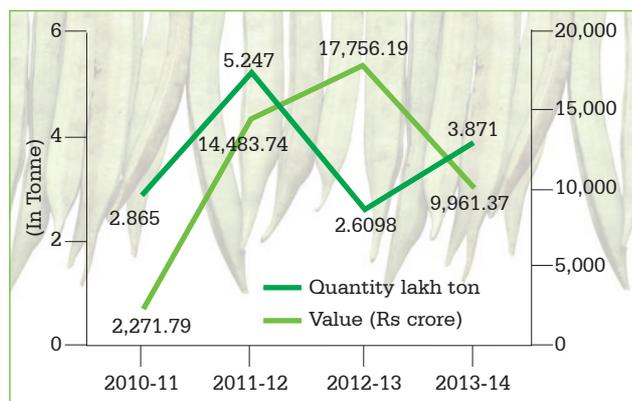


Figure 11: Export Statement of Guar Gum Treated and Pulverized from India

b) Guar Meal

The germ and outer seed-coat of guar seed together constitute guar meal. Removal of gum powder from guar seeds increase the protein content of the residual byproduct, i.e. guar meal. Guar meal is a light grayish material with beany flavor. The guar seeds contain in 62%-68% of guar

meal which is a rich source of crude protein content of about 35%-46% which is about 1.5 times more than protein in guar seed and comparable with other vegetable protein sources like oilseed cake used in poultry diets. Guar seed contains 4-5% oil content. It has been observed that the total protein of guar meal consist of 4 fractions, 2 of high and 2 of low molecular weight. It was observed that the guar oil contains 55.1% linoleic acid compared to only 51.8% in sunflower oil. The total unsaturated fatty acids were 78.7% and 92.0% in guar and sunflower oil, respectively. Guar oil contains 3.36% linolenic acid. The iodine value and refractive index of the guar oil are also well comparable with that of sunflower oil.

Guar meal contains residual guar gum (1%-1.8%) which is not easily digested and absorbed by the mono-gastric animals. It also consists of certain toxic substances lie trypsin inhibitors, saponians (10-12%), lignins, phytates (7%-7.5%) etc. which needs detoxification (source: D. Kumar, 2014).

2.2 Emerging Issues & Constraints:

2.2.1 Production:

A number of technologies for improved production of guar in reference to seed variety improvement, planting devices, agronomy, plant protection, fertility management, moisture conservation and quality aspects have been developed. The improved line sowing methods for guar are as indicated in (Fig: 12b).

Figure 12a: Broadcasting Method — common practice





Figure 12b: Line sowing Method — improved practice

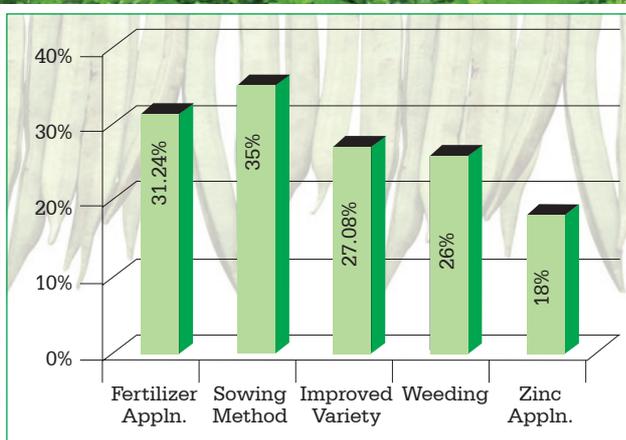


Figure 13: Contribution of different components in enhancing grain yield

Source: D. Kumar, 2013

There is a need to prioritize improved guar production methods with respect to their contribution towards yield, convenience and cost effectiveness. Figure 13 summarizes the results of large scale field demonstrations at Durgapur, Hisar, Bhatinda and Gwalior. From the figure it is quite clear that the planting or method of sowing is an important contributor for enhancing grain yield. The weeding method and variety of guar etc. follow the sowing method and fertilizer application in the priority list.

Thus, proper sowing method by adopting adequate plant population in reference to the rain fall and soil type may be adopted. Weeding is also very crucial, crop may be kept weed free up to 30-40 days of sowing. In addition to these, good quality seed must be addressed for the poor and marginal farmers for enhanced production. Table 13 shows few guar seed varieties and their suitability for different zones established through field experiments.

TABLE 13: Details of promising varieties of guar for different rain fall situations

Type of Variety	Maturity (Days)	Rainfall (mm)	Suitable Regions
RGM -112 HG-365 HG-563 RGC-936	85-90	300-400	Ganganagar, Hanumangarh, Barmer, Jodhpur, Hisar, Bawal, Rewari etc
RGC-1002, 1003, 1017 HG-884 HG-563	90-100	400-500	Nagaur, S.K. Nagar, Kothara, Jalore, Sirohi, Jaipur, Hisar, Anantpur, Chittoor, Kadappa etc

Source: Kumar and Rodge, 2014

2.2.2 Non-traditional areas and seasons:

Guar cultivation has now been transferred to the regions, where it was not being cultivated earlier. It is now being cultivated on rain fed lands in drier regions of Chhattisgarh, Andhra Pradesh, almost entire Maharashtra, parts of Karnataka and Tamil Nadu. These areas have potential due to better moisture conservation potential of soils. Almost 1500kg - 1800 kg/ha of grain yield have been achieved. Technological requirements for these areas to make full use of guar production potential have yet not been discovered.

2.2.3 Dissemination of proven technology

Most farmers cultivate guar crop on marginal lands in India. They lack resources like knowledge of latest agricultural technologies and finances. As such they are way behind others in technological awareness. Due to this, the production of guar as well as its quality has suffered. Institutional capacity exists in the country but it lacks adequate and planned utilization for dissemination of proven and established technologies among the farmers.



2.2.4 Early Maturity

Guar is grown as a rain fed crop. The growing period with rain fall pattern in state like Rajasthan is only 50-60 days, while this crop takes more than 90 days to mature. As such the crop has to sustain for more than 40-45 days with limited soil moisture. This is perhaps the main reason that full production potential of promising varieties of guar has not been realized in Rajasthan. Thus, early maturing varieties are required for this region.

2.2.5 High gum content and varied viscosity levels

In guar, across the varieties, the gum content does not vary considerably and ranges from 29% to 30.5% only. If the gum content is increased to almost 34%-35%, this will help in increasing guar gum yield. Unigenes for creating differences in size of endosperm have been identified therefore; biotechnological approaches must be utilized for acceleration of guar gum content and guar gum quality (Viscosity).

2.2.6 Processing and Products Developments

The fate and future of Indian guar farmers will largely depend on lifting of their crop produce at a reasonable price by the traders and ultimately by the guar gum industries. The future of guar units largely depend on effective functioning, manufacturing guar gum and the export of guar gum powder. Thus, ultimate focus rests on maximization of guar gum and its derivatives including value added products and the by-products including guar meal, churi etc. Thus, processing and need based products development by the industries are the key issues which need to be looked at.

Processing guar splits and guar gum powder involves extraction of splits and development of guar powder from the endosperm at small scale in the laboratory and at large scale in the industries for commercial purposes and exports.



Figure 14 shows step wise processing of guar seed for producing guar splits and guar gum powder

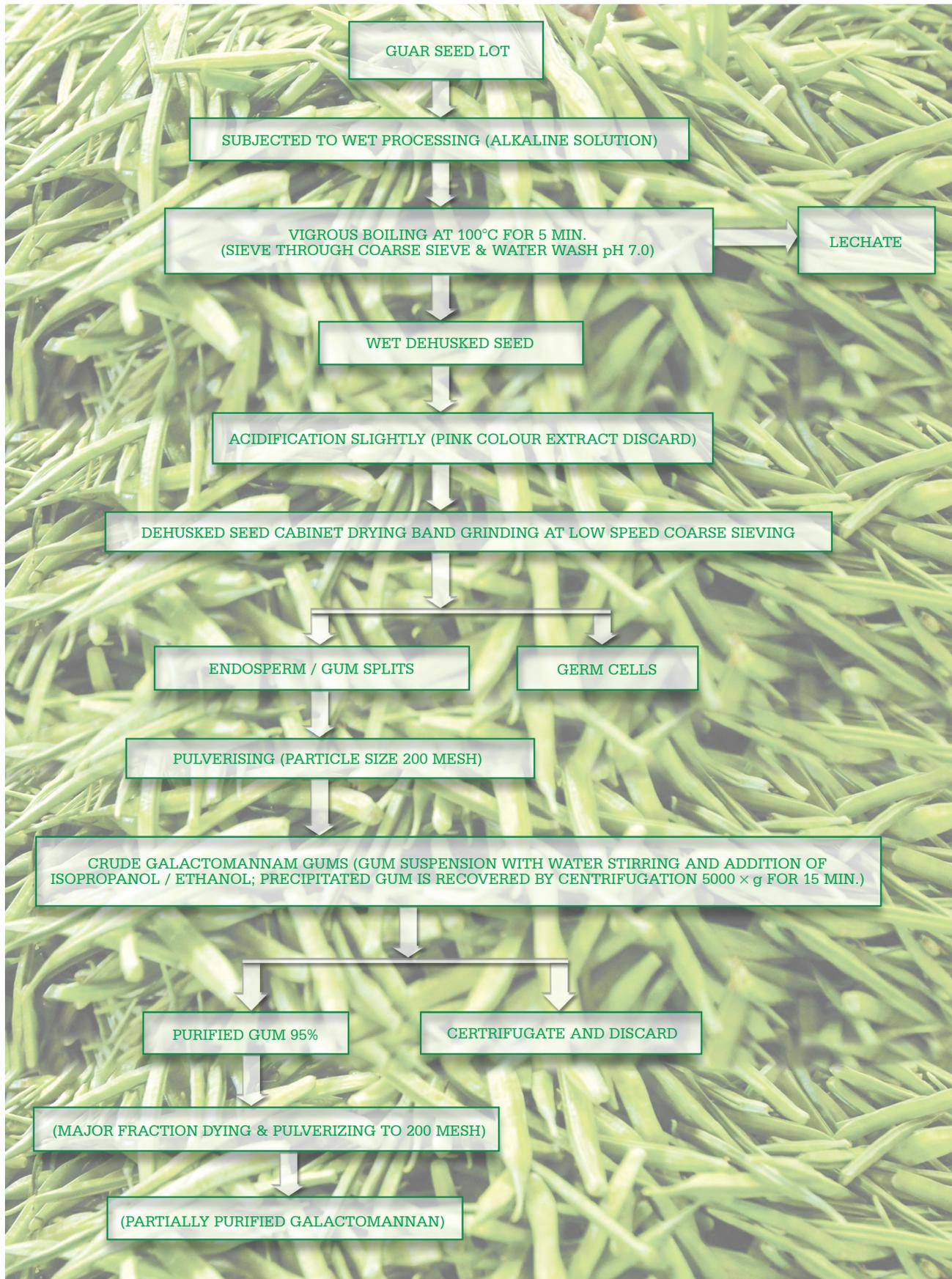


Figure 14: Processing of guar for producing splits and powder



Generally, split formation and guar gum powder production in guar gum manufacturing units, go sequentially. The capacity of a guar gum producing unit depends on number of guar split or guar powder manufacturing lines installed in a particular industry.

Technical challenges and problems in guar splits and guar gum powder processing:

- a) Generally guar seed contains 35%-37% endosperm; however, hardly 28%-30% endosperm is extracted. Thus, there is a net loss of almost 5% to 7% of guar splits or guar gum powder. This is due to poor extraction machines and methods. The same are age old, indigenous and not fully efficient.
- b) Hydration of splits is a crucial process after their extraction. However, hydration rate is very slow due to age old techniques. The higher hydration rate (Fann viscosity) is required for value addition of the products.
- c) Development of powder technology is not up to the mark. There is great powder loss during the process - mostly in hydration, flaking and grinding processes.

2.2.7 Value added Products and their Application:

Guar gum and its derivatives are being used in a number of industries. The guar gum industries have been looking for feedback from these industries for their production and use

in specific products. Unfortunately, guar gum units are still unable to innovate and manufacture any value added product by themselves.

Guar splits or the guar powder of desired viscosity is the only saleable items as of now. Also, there is lack of effective coordination between guar gum manufacturers and the consuming sectors (mining, textile, food, explosives, oil well fields, construction etc.).

2.2.8 Improving quality of guar meal:

Residual guar gum content if, more than 1.05% in guar meal will not be digested by the hens and chicken. Besides, certain toxic substances like trypsin inhibitors, saponians also deteriorate the quality of guar meal. Hence, remedial measure and improving quality of the feed is required.

By Pass or Protected Proteins: These are the dietary proteins those pass intact from rumens to lower digestive track, where these are hydrolyzed enzymatically and absorbed as such.

Ruminants have 4 stomach, where 80 % proteins from guar meals are broken down and rest 20 % are absorbed in the intestine. Thus, considerable proteins are lost, wasted and extracted in urine as uric acid (Manchanda, 2014).





3.0 TIFAC WORKSHOP: OVERVIEW & PRESENTATIONS

OVERVIEW

With a prime focus on technology, a Brainstorming Workshop on ‘Boosting of Guar Gum Exports: Technical Needs and Requirements and the Way Forward’, was convened on 29th May 2014 at Jodhpur focusing on the ways and means towards enhancing the export of guar and its derivatives (guar splits, guar gum powder and other derivatives) from India. It was attended by about seventy (70) representatives of a wide ranging stakeholders including Choudhary Charan Singh Haryana Agricultural University (CCSHAU), Hisar; Central Arid Zone Research Institute (CAZRI), Jodhpur; National Institute of Agricultural Marketing (NIAM), Jaipur; Directorate of Soyabean Research (an ICAR Institute), Indore; Well Stimulation Services of Oil and Natural Gas Corporation (WSS ONGC) Ahmadabad; Forest Research Institute (FRI), Dehradun; Indian Institute of Chemical Technology (IICT), Hyderabad; representatives of few State Govts, representatives of Indian Guar Gum Manufacturers Association (IIGMA), Jodhpur, entrepreneurs from Guar Gum industries (Lotus gums, Sreeram Gum & Chemicals, Hindustan Gums, Sunita Hydrocolloids Pvt. Limited, Jai Bharat Gums and Chemicals, Siwani, Haryana etc.), Officials from TIFAC, New Delhi and other traders & businessmen also participated in the Workshop.

The Workshop was inaugurated by Mr. Giriraj Singh, Hon’ble Member of Parliament from Bihar. The function was chaired by Dr Prabhat Ranjan, Executive Director, TIFAC, New Delhi. Dr (Mrs.) Debjani Roy, Executive Director, Shellac and Forest Product Export Promotion

Council (SHEFEXIL), Kolkata, was the Chief Guest of the function.

Dr. Debjani Roy Executive Director, SHEFEXIL, highlighted the importance of guar gum and stressed on the need of value additions in guar gum. In her address she touched upon various aspects like guar application, exports performance, gaps and steps needed for enhancing guar exports as follows:

Applications of guar gum: Two decades back guar gum had majority application in the food industries as an additive. It found major applications in bakery, processed cheese, soups, pastry, meats, dressings, and sauces and beverages. However now-a- days, the application is skewed towards industrial applications such as textiles, oil well drillings, mining, construction, explosives, cosmetics, paper and pharmaceuticals.

Export Performance in last 5 years:

The export performance of guar gum has grown substantially in last 5 years, despite a dip in the last year. In US \$ million, the export figures were 239.15 (2009-10), 621.29 (2010-11), 3354.82 (2011-12), 3958.90 (2012-13) and 2344.95 (2013-14).

In volume the exports in MT were: 406312 in 2012-13, while in 2013-14 exports were 464256 for actual 11 months only.

Thus, in dollar terms, there has been a significant positive growth for 4 years, followed by a steep negative growth in the 5th year. However, negative growth in revenue is offset by volume growth of approximately 14%.

Figure 15: Brainstorming Workshop at Jodhpur on 29th May, 2014





Figure 15: Brainstorming Workshop at Jodhpur on 29th May, 2014

Gaps in Guar Gum Industry Competence:

The Indian guar gum manufacturers even today do not know how to derivatize guar which is a value added variant product. Very few also really know how to manufacture high value HVG (USA patent). These value additions must be learnt if India as a country must earn for their raw material.

Some Prescriptions for enhancing exports:

- ❑ More area of high yielding and early maturing varieties of guar may be brought, to increase seed replacement rate.
- ❑ Moving towards market preferred varieties - high gum content and high viscosity.
- ❑ Decisive steps in R& D in guar.
- ❑ Common Export Facilities Centre for producing and packaging value added products using guar gum in Jodhpur.
- ❑ Hydrolyzed guar for dietary use.
- ❑ Cationic guar for personal care use.
- ❑ Hydroxy propyl guar for construction, personal care oil field uses.
- ❑ Odorless and tasteless guar for use in food.
- ❑ Removal of odor of guar meal and its use as a protein supplement for human consumption
- ❑ Development of high yielding varieties / high viscosity for fast hydrating guar.

3.1 Presentations

Issues and Challenges before the Industries

3.1.1 Technical Issues and Challenges of Guar Gum Industry - Needs & Requirements by Shri Purushottam Hissaria, President, Indian Guar Gum Manufacturers Association (IGGMA)

Mr Hissaria, M. D., SHCPL, Jodhpur spoke on issues and challenges in agronomy, cultivation and the varieties of guar; processing of guar seeds and the endosperm; R&D, values addition and applications; policy and regulations. He highlighted some issues being faced by guar gum industries as below:

Need for continuous R&D on novel guar based products and their industrial applications –

- ❑ Around 90% of fast hydrating guar powder is being used in the oil & gas industry. But, there are technical issues related to quality like low thermal stability, higher RAB value, low salt tolerance etc. Need is there to address these quality parameters.
- ❑ Value added guar based products like Hydroxy Propyl Gum (HPG), Carboxy Methyl Gum (CMG), Carboxy Methyl Hydroxy Propyl Gum (CMHPG) are required by oil & gas industry for mitigating problems of fast hydrating guar powder. Production technology for these high value derivatives products is not available.
- ❑ Other derivatives of guar like cationic, anionic, cross linked and depolymerized guar are being manufactured by Indian guar industries for various applications. There is definite scope to improve these derivatives through technology infusion.



Figure 17: Sh. Purushottam Hissaria, President, Guar Gum Manufacturers Association, sharing problems and challenges of guar gum industries

Threats:

- ❑ Substitutes have been developed to replace guar, partially or completely, especially in Oil & Gas sector.
- ❑ Cheaper hydrocolloids like Sesbania gum, starch, TKP, CMC etc. have replaced guar products from various industrial applications like food, paper, textile, mining etc because of fluctuating and high prices of guar.
- ❑ Increasing International Competition: Cultivation of guar crop has been started in USA, China and Australia. Guar processing industries have been established in USA, China and Oman. Weak logistic infrastructure in India causes delay in shipments which poses problems for export industries in this era of competition.

Policies and Regulations for Guar Industry:

- ❑ There is huge fluctuation in guar pricing. Stability in guar raw material prices is required.
- ❑ Export of value added guar products require encouragement and incentivization.
- ❑ Guar crop forecasting and authentic crop data is unavailable. As such the industries could not estimate the regional and overall production level. The forecasting and crop data logging techniques are strongly needed.

- ❑ There is no exclusive government department / agency to solve issues related to Indian guar industry.

Suggestions:

- ❑ Controlling Price Fluctuations: Policy may be drafted to keep prices of guar raw material reasonable / stable.
- ❑ Cost effective technologies should be developed to manufacture value added guar products to compete on global level.
- ❑ Survey of Indian guar crop may be done by government agencies towards providing a clearer picture of raw material availability, prices, demand etc.
- ❑ Exclusive, single window mechanism/nodal agency system should be established for Indian Guar industry.
- ❑ Increase in incentives on export could boost guar exports.

3.1.2 Enhancing Guar Grain Production: Short Term & Long Term Strategies by Dr. D. Kumar, Principal Scientist (Retd.), CAZRI, Jodhpur & Guar Gum Consultant

Dr. Kumar highlighted issues related to main constraints and the way out, summed-up as below:



Practical Constraints:

Growing conditions of the crop in question are fragile and uncontrollable, farmers mind set is difficult to be changed. Farmers are not interested in making required investments in cultivation of guar. Inputs are becoming very costly. Therefore, the constraints are of general in nature but have been specifically and judiciously bracketed as below:

- a) **Availability of Pure Seed:** The pure seed of desired variety is still not available. Public seed supply organizations have not been successful so far provide the desired quantity and quality of seeds. On the other hand private sector companies in seed supply/private entities are interested in production of hybrid seeds only. If good quality certified seed is made available in desired quantity, it can definitely increase the grain yield by about 25% - 30% by keeping factors constant. It has been estimated that nearly 36,000 ton certified seed is required to sow almost 30 lakh ha of land each year.
- b) **Planting Technology:** Depending on rainfall, the tractor mounted seed planting devices are essentially required in just 2 to 3 days of rainfall (for rainfall regions in the range of 30mm - 40 mm) to cover large acreage (25 lakh ha - 30 lakh ha) of guar cultivation. Delayed sowing may lead to poor plant stand

- (number). Small and marginal farmers lack financial resource to purchase tractor mounted planters. Mechanism need to be in place/developed for making latest planting equipments available in advance on rental basis at the village / panchayat level which can sow seeds quickly and methodologically. It is to be noted that there are large cultivable area in Rajasthan alone (25 lakh ha - 28 lakh ha) which are difficult to be sown in just 2-3 days after rain by traditional planting methods
- c) **Weeding:** Arid guar farmers do not believe in inter culture operations. This is mainly due to additional labour cost for weeding and lack of awareness about the advantages of weeding. Awareness need to be given to farmers about the benefits of inter-culture weeding as this practice can conserves soil moisture, makes it available to the roots and clears shelter of insects and pests which damages the crop. In the absence of proper weeding the grain yield may reduce by 35% - 40%.
- d) **Supplementary irrigation:** In case of absence of rainfall for as long as 40 days, only one supplementary irrigation at the podding stage perhaps from the water collected in the pond near fields only, may revive plant life and may give 40% - 45% more grain yield. This practice need to be popularized.

Figure 18: Dr. D. Kumar, delivering talk on enhancing guar grain production





Technical Constraints:

- a) Growth period: Presently, there is no variety of guar which is maturing in less than 90 days. *S. serrata* wild guar species can be a source of earliness for guar crop (with maturity in 45 - 50 days). There is however, need to cross *S. tetra* and *S. tetragonoloba*, through ovary rescue or protoplasmic fusion by non-conventional measures.
- b) Need based improvement in plant type: Initial fast growth, lesser number of secondary branches, enhancing length of main shoot with dense podding behavior and better source-sink relationship, less biomass and more reproductive area, more synchronization in flowering, podding and maturity behavior, less loose canopy, semi-spreading to erect canopy behavior etc., is required. These may provide early maturity (70 to 75 days).
- c) Improved gum qualities: High gum (> 35%) content with varied viscosity levels in guar seed are required for use in manufacturing of different products of food and industrial grade.

Observations and Recommended Approach for Enhancing Grain Yield & Gum Content:

- (i) During summer season, almost 2.5 to 3 times more grain yield, 1.5 to 1.7%, more gum content, 320 kg/ha more gum yield and 330-340 cP more viscosity of guar gum could be realized vis-à-vis the kharif season.
- (ii) In kharif season, from amongst various nutrient soil fertility treatments maximum grain yield (901 kg/ha) was realized with Nano P (40 ppm), maximum gum content (31.03%) with Nano Zn (10 ppm), and maximum viscosity, with basal Zn (25 kg/ha) was realized.
- (iii) Amongst varieties, RGC-1066 and RGM-112 were characterized with maximum gum content (31.46%) and viscosity profile (4535 cP), respectively.
- (iv) Guar can be cultivated in black cotton, heavy soils provided there is no water logging conditions.
- (v) For Southern and central India, summer sowing is more suited than sowing crop during rainy season.

Other Observation:

Need for Energy Audit: Dr. Kumar also stressed on the need to make the existing processes and machinery in guar industries more energy efficient and environment friendly. He pointed out that of the total energy consumed during processing of guar gum 30% and 20 % are in the form of electricity and gas, respectively. To maintain a single guar

gum industry 1500 KW of electricity may be required. If the cost of energy is estimated to Rs 5.50/unit then it is equivalent to about one unit per kg of guar gum powder, which is very much on the higher side.

Suggestions:

- ❑ Power requirement should match the load.
- ❑ Load factor must be as per load contact (it is generally 50%-60%).
- ❑ Plant machinery and the operators must be efficient.

For this he concluded there is need to conduct the energy audit of guar gum industries to help them save energy and thus increase profits margins by way of energy savings.

3.1.3 Manufacturing and Utilization of Guar Gum - Technical Problems and Challenges by Dr. S.K. Sharma, Lotus Gum, Jodhpur

Mr. S.K Sharma M.D., Lotus Gums and Chemicals, highlighted the history of guar crop and guar gum industries right from 1953 till date. He gave complete description of guar plant, its classification, vernaculture and complete guar cultivation including, guar crop growing period in India, seed karyo type dealing with seed coat, embryo, endosperm, guar gum properties, types of gum, its uses, chemical aspects of guar gum. He also highlighted the particle size (300-60 MESH) and range of viscosity (3000-9000 cP) required for guar gum products.

3.1.4 Improving quality of Bi-products of Guar Gum for feeding by Shri Somnath Manchanda, Dy. Manager Feed Plant, Jodhopur

Sh. Manchanda suggested setting up of By Pass Protein plants along with the guar gum industries for producing better quality of feed which may enhance digestion and absorption of guar meal proteins in animals. Sh. Manchanda also highlighted on the need to improve guar meal against constituents like trypsin inhibitors, saponians, lignins etc.

3.1.5 Sustaining Guar Industry in India - Some Technical and Policy Issues by Dr. Hema Yadav, Deputy Director, National Institute of Agricultural Marketing (NIAM), Jaipur

The major points highlighted by Dr. Hema Yadav are as follows:



Shift of Industry from Food Grade to Fast Hydrated Gum Grade

The insights into the industry revealed that there has been a migration of guar demand from food grade to industrial grade. The food grade gum has been substituted by synthetic gums for achieving price competitiveness in food products. At the same time the emergence of demand of Guar from the US petroleum industry and also the oil fields of Middle East has changed the scenario.

Prior to 2005, the major demand from the industry was for food grade Guar gum. In Europe, Guar gum has EU food additive code E412. Xanthan gum and Guar gum are the most frequently used gums in gluten-free recipes and gluten-free products demand for the food grade Guar gum was around 50% of the total Guar gum consumed. The consumption of Guar gum by oil drilling industry was limited to around 30%. But at present the scenario has change and the major consumer of Guar gum is oil drilling industry while the chunk of demand from food industry has reduced to around 20% only as depicted in figure 19 below:

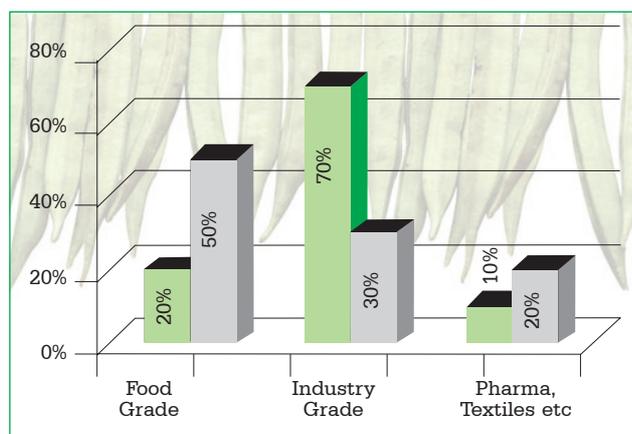


Figure 19: Past and Present Use Pattern of Guar Gum

Expansion of the Shale Gas Industry

The expansion in uses of guar to new areas like extraction of natural and shale gas has transformed guar in recent years into an important export crop. The introduction of hydraulic fracturing also known as fracking in the extraction of natural and shale gas has provided a new dimension to the energy industry. The use of fast hydrated gum as a key ingredient in the process of fracking has helped consolidate the demand of crop in the international market.

The increased demand has contributed towards an escalating impact on the prices of guar in the recent past.

The cultivation of crop mainly under rain fed conditions and its confinement to limited geographical area leads to uncertainty and volatility in the prices.

The prices and export estimate based on the analysis are presented in table 14. The prices of guar in 2014-15 are expected to rule high based on the expanding demand from the shale gas industry. From Rs 8,832/Qt in 2014 it is estimated that the price of guar in 2020 will reach to Rs 11,729/Qt. The prices are expected to rule high even when it is assumed that the production of guar crop in the country will increase roughly at six percent per year. It is expected that the increase in demand will surpass the supply which will result in high prices.

TABLE 14: Prices and Export Estimates of Guar

Year	Price (Rs/Qt)	Export (in thousand MT)	Shale Gas (tcf)
2014	8832	959	8.66
2015	10111	978	8.85
2020	11729	1192	11.05

Note:

- (i) Shale gas estimates have been obtained from EIA,
- (ii) Production has been assumed to increase at a CAGR of 5.75 %,
- (iii) Export and Price estimates have been worked by authors

Supply of Guar: Important Factors

The supply response of a crop may be estimated in terms of area, yield and output response. The study focuses on area and yield response. In economic analysis of the dynamics of farm supply response, price is usually considered the most critical factors which influence farmer's production decisions (Khan et. al., 1988). However, acreage under a crop is also influenced by various factors other than prices.

Other factors influencing supply response include weather, risk, and relative productivity. The crop being rain-fed may be affected by the variability in intensity and pattern of monsoon during the sowing season. Since the crop is not covered under prices support policy and experienced high price fluctuations in recent years, the risk associated with the prices of crops may also play an important factor in defining acreage under the crop. Relative productivity of Guar is important as a profit oriented farmer will opt for most profitable crop.

Guar is most important crop of kharif season after Bajra in Rajasthan being cultivated on an area of 2.91 million hectares, more than 21 percent of total area under kharif crops in the state. Other important crops are maize, mung and groundnut. All the crops are covered under MSP



system except guar. Groundnut is one of the most profitable with ability to take care of immediate cash requirement of the farmers. Guar though always had the favorable characteristics like low input requirement, low maintenance, drought tolerant and improving soil fertility but was placed weak in terms of productivity per hectare in comparison to other kharif competing crops like bajra, mung, maize and groundnut. But favorable price movement in recent years has changed the entire scenario of guar crop and guar processing industry in India. An elementary analysis showing relative profitability (Rs/ha) of gura crop viz-a-viz other leading crops of kharif season has revealed that a price even in the range of Rs 4000 will make the guar relatively better place to cash crop like groundnut.

TABLE 15: Relative Productivity of Competing Crops during Kharif in Rajasthan (average of 2010-11 and 2011-12)

Crop	Productivity (Qt/ha)	Price (Rs/Qt)	Revenue Generated (Rs/ha)	Cost of Cultivation (Rs/ha)	Net Returns (Rs/ha)
Maize	16.89	930	15712	19810	-4098
Groundnut	19.47	2300	*44779	30114	14665
Mung	5.65	3335	18845	9166	9679
Guar	5.56	3900	21684	7000	14684

Source: Department of Agriculture, Government of Rajasthan, agmarknet.nic.in, data.gov.in

Note: Cost of cultivation figure for groundnut is from Gujarat, cost considered for analysis is cost c2 and cost of cultivation for guar in Rajasthan is worked out on field survey response recorder from Jaipur and Sikar District.

Since the crop is having numerous other benefits like minimum input need, low maintenance, soil conserving, assured supply of fodder to a livestock reach agriculture, the farmers may maximize their profits by bringing more area under guar cultivation by diverting area from other competing crop. The farmers who were growing guar traditionally started shifting to modern technology and use of high yielding varieties. The field survey reveals that majority of the farmers are well versed with all the technical knowledge required for production of guar, different cultivation practices and market price prevailing in different markets. Farmers are now more vigilant than earlier while dealing in guar. Given that the demand for guar is expected to increase for its use in shale gas industry along with other uses, the farmers may maximize profits by making larger quantity of guar available at reasonable price than lesser guar at higher prices. The regular supply of guar at competitive prices will also boost the processing industry in India and will not force the shale gas industries and other industries to search for alternatives.

Addressing Challenges and Technical Roadmap

3.1.6 Guar Gum Supply Chain: Issues and Options by Dr. Purushottam Sharma, Senior Scientist (Agricultural Economics), Directorate of Soyabean Research (ICAR), Indore

Dr. Purushottam Sharma presented the issues related to cost effective crop cultivation cheaper and factors related to guar supply chain (seed to grain). Dr. Sharma covered various options for enhancing guar supply chain and options for the industries to increase business. He suggested that proper assessment to be done towards identifying the gaps in guar supply chain and its availability to the industries. He also highlighted on the role of industries to support the farmers in stabilizing yield levels, achieve higher productivity and minimize post production prices.

3.1.7 Derivatization of Guar Gum - Derivatives in Demand, Indian Scenario, Future Needs and Possibilities by Dr. Vineet Kumar, Scientist - F, Chemistry Division, Forest Research Institute (FRI), Dehradun

Dr Vineet Kumar highlighted the importance of guar cultivation and its importance for industries. Dr. Vineet stressed on the need for developing newer guar gum derivatives to match the industrial applications as follows:

- ❑ Hydroxypropyl guar for construction, personal care, oil well drilling etc.
- ❑ Double derivatives of guar like hydroxyl propyl and carboxy methyl guar for specialized industrial applications.
- ❑ Galactose depleted guar for gelling applications.
- ❑ Cationic guar for varied applications in pharmaceuticals, personal care, paper and pulp etc.
- ❑ Hydrolysed guar as dietary fiber and other pharmacological applications.
- ❑ Odorless and tasteless guar for food and feed.
- ❑ Development of fast hydrating high viscosity guar for oil well drilling, food and other applications.
- ❑ Organic guar (certified) for food and feed.
- ❑ Removal of odour of guar meal and its use as a protein supplement for human consumption.

Presentation also highlighted the huge demand for guar derivatives due to their extensive applications in a number of industries such as petroleum, textile, paper, food, pharmaceuticals etc. Explicit end use applicability of the derivatized specialty product in industry is exceedingly expensive and in very high demand.



Concern: Surprisingly, derivatized products are being imported in the country at a very high value as Indian industry is way behind to derivatize the guar gum in comparison with US, Europe etc.

Suggestion: Therefore, a systematic approach towards derivatization and value addition is required by investment in research and development within the country. But hardly any efforts are being made in this regard in the country. To achieve the same and to make the country self reliant, systematic and concerted efforts are required to strengthen research-industry linkage as research institutes lack funding and support for guar research. Industrial houses must share their problems related to research requirements. To achieve this, strong interface needs to be developed between the industry and research institutions with the support of Govt. agencies. There is also a need to invest heavily into R&D for guar gum derivatization and value addition upto pilot and commercial scale for the benefit of the society at large.

3.1.8 Chemical Modification of Guar with Special Reference to CMHPG and HPG: Technical Aspects for Consideration by Dr. T. Shekharam, Sr. Principal Scientist, CSIR-IICT, Hyderabad

Dr. Shekharam highlighted the importance of guar with

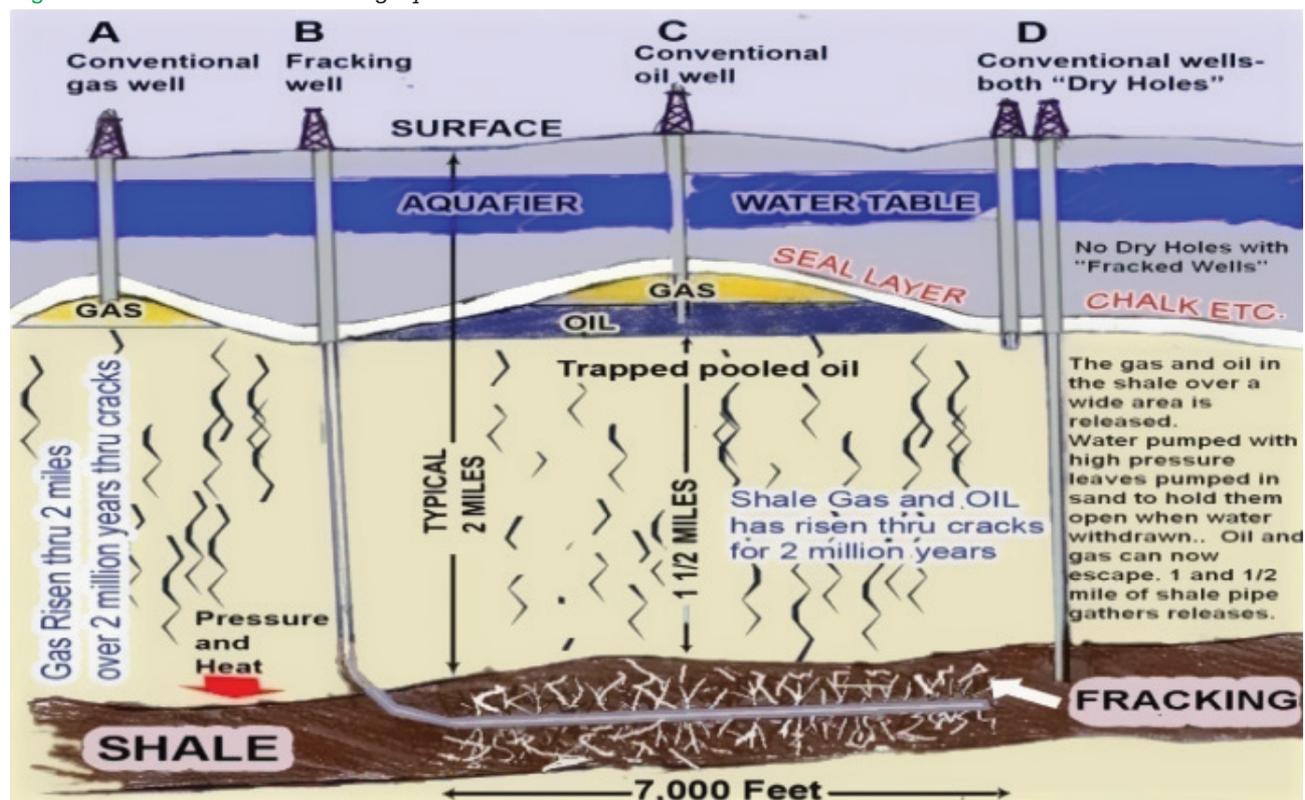
respect to derivatives like Carboxy Methyl Hydroxy Propyl Guar (CMHPG - double derivative) and Hydroxy Propyl Guar (HPG - single derivative) high value products and their uses in fracturing and drilling fluids. Presentation focused on chemical synthesis of guar derivatives for oil and gas industry, summarized as below:

Important properties of guar for oil & gas exploration purpose:

- ❑ Guar gum has very high molecular weight (approx. 2.0 million).
- ❑ It is comparable to a variety of inorganic and organic substances including certain dyes and food constituents.
- ❑ It is having excellent stabilizing, thickening and emulsion properties. It is moderately tolerant to soil salinity.
- ❑ It has strong hydrogen bonding properties.
- ❑ On average basis 20,000 lbs guar gum is consumed for fracturing one well, which equals to produce from 100 acres.

The simple schematic of oil drilling operation is as shown in fig. 20 below:

Figure 20: Schematic of Oil Drilling Operation





A Simple schematic showing chemical synthesis of HPG and CMHPG (Fig. 21 & Fig. 22) is as shown below:

Chemical synthesis of HPG from guar gum:

Type of reaction during synthesis:

1. Slurry
2. Suspension

Variables that control properties of HPG during synthesis are:

1. Quality of raw material
2. Air OR Inert atmosphere
3. Stoichiometry of reagents
4. Rate of additions
5. Temperature, pH
6. Base employed

Recommendation: HPG, CMG and CMHPG can be indigenously developed with proper support from Govt. and through a mission mode approach.

3.1.9 Guar Research at CCS, Haryana Agricultural University, Hisar, by Dr. U.N. Joshi, Senior Biochemist (Arid Legumes) and Head, Biochemistry Department, CCS, HAU, HISAR

Dr. U.N. Joshi presented the work going on in CCS HAU, Hisar, regarding plant improvement, agronomical aspects, biochemistry, tissue culture and efforts being made on non-traditional approaches for developing earliness in guar. Dr. Joshi briefed on the best practices for guar cultivation and elaborated the progress made by HAU in development of some promising varieties of guar along with yield achieved and gum content as shown in Table 16:

Figure 21: Chemical synthesis of HPG from guar gum

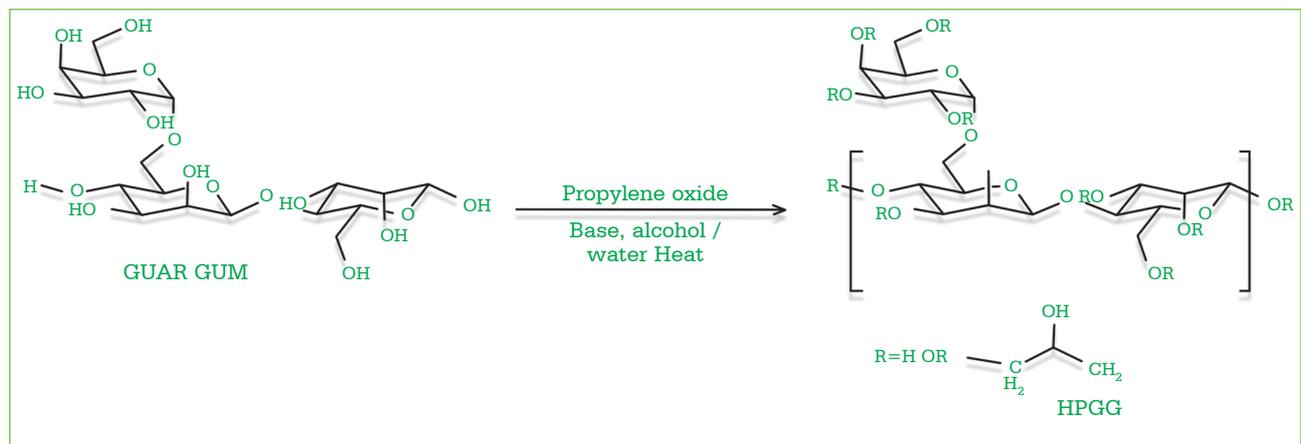


Figure 22: Chemical synthesis of CMHPG from guar gum

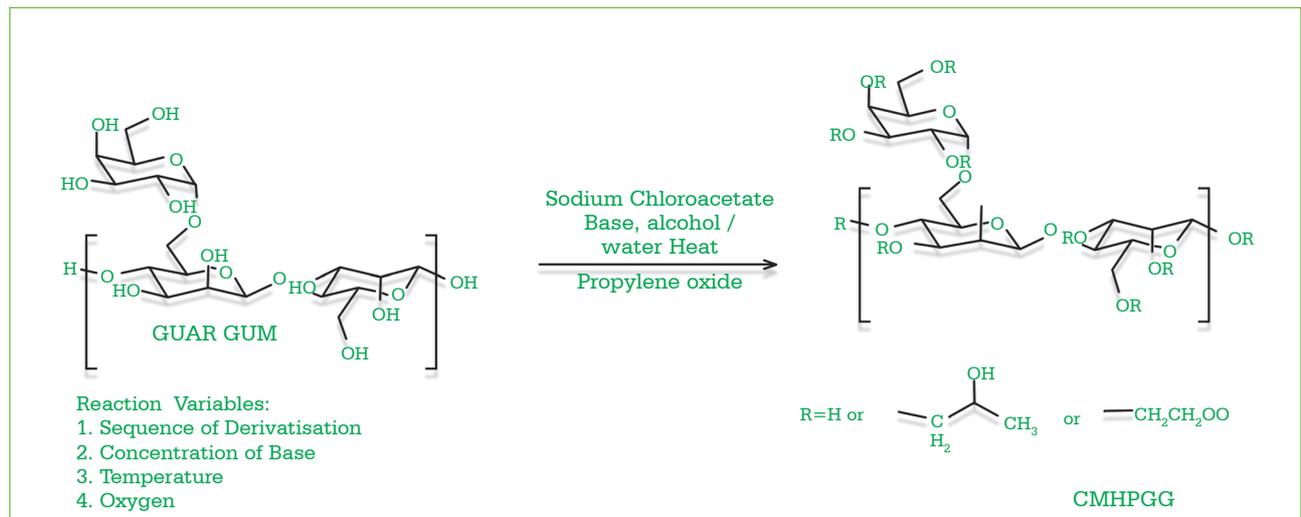




TABLE 16: Guar varieties developed at HAU, Hisar

Varieties	Grain Yield (q/ha)	Gum (%)	Viscosity (mpas-1)
FS 277	8-10	29.58	-
HG 182	12-14	30.52	-
HG 258	15-17	29.10	-
HG 75	16-18	30.36	1932
HG 365	18-20	31.51	2992
HG 563	18-20	30.92	3903
HG 870	18-20	31.34	3702
HG 884	20-22	29.91	2568
HG 2-20	21-23	30.26	2749

Source: Department of Agriculture, Government of Rajasthan, agmarknet.nic.in, data.gov.in

Note: Cost of cultivation figure for groundnut is from Gujarat, cost considered for analysis is cost c2 and cost of cultivation for guar in Rajasthan is worked out on field survey response recorder from Jaipur and Sikar District.

Dr. Joshi also listed some promising guar lines (not released varieties) having high gum Content (>35%), which can be used in increasing gum content in other wise promising varieties of guar as follows:

TABLE 17: Guar varieties with potential of high gum content

Sr.No.	Germplasm	Gum (%)
1.	DG8	35.35
2.	GP147-48-01	35.70
3.	SPSG96	35.70
4.	IC116616	36.23
5.	IC116709	36.75

3.1.10 Gelling Agent - II (A guar derivative) ONGC

Perspective - by Dr. P.K. Mahato, Chief Chemist & Dr. A.K. Jain GM (Chem.), Well Stimulation Services (WSS), ONGC, Ahmedabad

Dr. P.K. Mahato, & Dr A.K. Jain presented the perspective of ONGC (user). The talk concentrated on the issues of importance; use of guar gum in ONGC, specification, price fluctuation, major issues, stimulation of oil wells, their

drilling, hydraulic fracturing, typical frac location set up, desired properties of frac fluid, typical drilling rig, drilling mud system, consumption of GA, Gd-2, Indian shale gas prospects, Indian shale gas exploration, ONGC specification etc. Dr. Jain also explained to the industries about the specific requirements of guar by ONGC.

3.1.11 Dr. Keka Ojha, Associate Professor, Indian School of Mines (ISM), Dhanbad

She could not personally attend the workshop, but contributed through a detailed write-up. The write up highlighted applied aspects of guar products in the mining sector. Some of the salient inputs provided are as given below:

Typical fracturing fluid volumes for different reservoirs:

It is estimated that 70 - 140 billion gallons of water are used to fracture 35,000 wells in the United States each year. This is approximately equivalent to the annual water consumption of 40 to 80 cities each with a population of around 50,000. Fracture treatments in coal bed methane wells use from 50,000 gallons to 350,000 gallons of water per well, while deeper horizontal shale wells can use anywhere from 2 - 10 million gallons of water to fracture a single well.

Conventional oil and gas wells use on an average 300,000 pounds of proppant, while coal bed fracture treatments uses anywhere up to 75,000 to 320,000 pounds of proppant and shale gas wells uses more than 4 million pounds of proppant per well.

No guar substitute has yet been developed that is as effective for high-viscosity hydraulic fracturing, although service companies like Halliburton, Baker Hughes, Schlumberger, are working on developing synthetic polymers whose properties might rival those of guar gum. As per several sources, out of the total amount of guar gum

TABLE 18: Grades of CMHPG and HPG for oil drilling

	CMHPG		HPG		
	ECOPOL18Y2	ECOPOL18Y2LMS	ECOPOL400	ECOPOL 400DS	ECOPOL400 LMS
Appearance	Light yellow Powder	Yellow orange liquid slurry	Light beige colour powder	Light beige colour powder	Yellow slurry
Particle Size	100% through 100 mesh	100% through 100 mesh	100% through 100 mesh		
Moisture, Wt %	6.0-10.0		6.0-10.0	6.0-10.0	
Ash, Wt %			1.0-3.0	1.0-3.0	
pH of 1% solution	8.5-10.5	9.0-11.0	9.0-11.0	6.0-7.5	5.0-6.5
Viscosity 1% solution or slurry	3000-4500 cps	1000-2000 cps	6000-7000 cps	6000-7000 cps	1000-2000 cps



TABLE 19: Grades of CMHPG and HPG used for other applications

	CMHPG		HPG			
	ECOPOL 18	ECOPOL18S	ECOPOL120	ECOPOL 120S	ECOPOL400	ECOPOL400S
Appearance	Light yellow colour powder					
Particle Size	100% through 100 mesh					
Moisture, Wt %	6-10	6-10	6-11	6-11	6-10	6-10
pH of 1% solution	8.5-11.5	5.0-7.5	8.5-11.5	5.0-7.5	8.5-11.5	5.0-7.5
Viscosity, 1% aq solution or slurry	3000-4000 cps	3000-4000CPS	1000-2500 cps	1000-2500 cps	3500-5000cps	3500-5000cps
Viscosity, 1% in 80% aq. alcohol			500-1000cps	500-1000cps		

used in hydraulic fracturing, about 80% is straight guar gum powder and the remainder consists of the guar derivatives like HPG, CMG, or CMHPG. The various grades of CMHPG and HPG used for oil drilling applications and for other applications are as shown in table 18 and table 19.

Guar Gum in Drilling fluid: Oil drilling and mining industries use guar gum to thicken the drilling fluids which

carry cuttings from the drill bit to the surface as the drill bit circulates up and down the borehole. Guar-thickened drilling fluids injected into rock formations are cross-linked to form a semi-solid mass which supports the walls of the formations as oil is extracted. Guar acts as a controlling agent in oil/gas wells to facilitate easy drilling and prevent fluid loss. It is also used as a top-hole drilling fluid. The typical hydro fracturing job for oil and gas drilling is shown in figure 23.

Figure 23: Typical hydro -fracturing overview

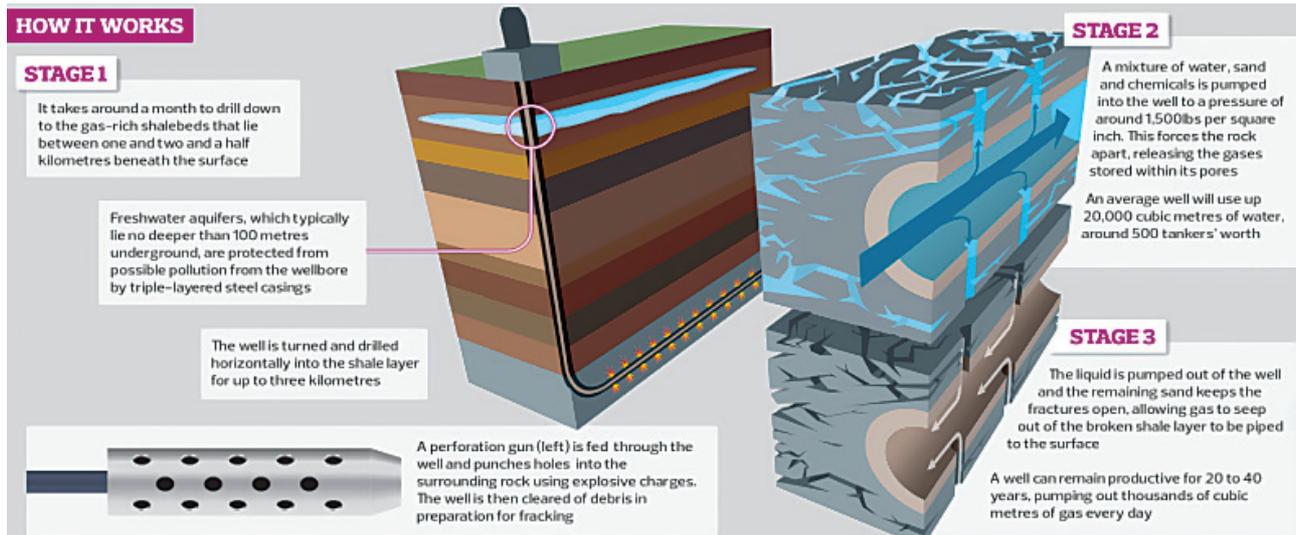
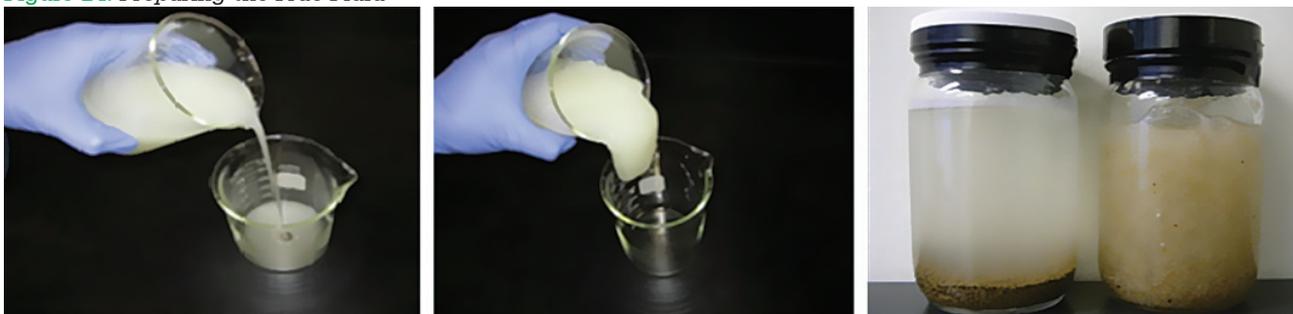


Figure 24: Preparing the Frac Fluid





Frac Fluid: Hydrated Guar Gum can be cross-linked with a Borate ion to produce an extremely viscous suspension at a relatively low gum concentration. A pH of 9-10 is required to produce the cross-link, which can be reversed by lowering the pH to neutral (7.0). The ratio of Guar Gum to Tetra borate should be approximately 5:1.

The primary gelling agent used in fracturing fluids is guar. Derivatives of Guar such as HPG and CMHPG are also used as gelling agents. Non guar-based gelling agents are hydroxy ethyl cellulose (HEC), carboxy methyl cellulose (CMC), and xanthan. All of these gelling agents are water soluble polymers that increase the viscosity of water. Advantages of guar gum over other polymer that makes guar the most preferred option towards its use in the frac fluid are the following:

- ❑ Highly effective, economical viscosifiers; 8 times more thickening power than starch
- ❑ Hydrates quickly in cold water
- ❑ Delivers proppant more effectively
- ❑ Stable at high pressures, heat and pH levels
- ❑ Yields quickly under relatively low-shear conditions Friction reducing properties
- ❑ Environmentally friendly; Natural substance used as a food additive Bio-degradable Functions in fresh, sea, and brackish water
- ❑ Safe to handle

GUAR in Enhanced Oil Recovery (EOR): The unique characteristic of guar gums in terms of rheological properties is that not only they owe significant viscosity values at lower concentrations in aqueous solutions but also they can exhibit excellent synergism. This feature, i.e. synergistic effect, has drawn much attention in some important applications especially in enhanced oil recovery (EOR) field.

Guar and its derivative are used in EOR as a displacing agent to oil by controlling the mobility; thus enhances the overall sweep efficiency and recovery factor. Guar gum is also used in water shut-off job where highly permeable zones are plugged to reduce/stop water flow from reservoir along with water.

4.0 RECOMMENDATIONS AND ROAD AHEAD

Looking at the overall scenario, there is an urgent need both in the short and long term for strategies to be planned including prioritization of R&D, and executed to tap the market potential to the maximum extent - both present and emerging. The steps are broadly categorized in two distinct categories - Dissemination of Best Practices and Trajectory of R&D Efforts, as detailed below:

4.1 Dissemination of Best Agricultural Practices

4.1.1 Seed:

Because of its rain fed nature, seed is very crucial and an initial input for the guar crop. Keeping other aspects at par, good quality seed may improve the grain yield by almost 20%-25%. Mostly, certified seed of confirmed quality is not available to the farmers. Efforts need to be undertaken to make the certified seeds available to the right person at the right time. Seed replacement ratio also to be kept at 15%-20% annually. At present, it is hardly 5%-7%. A compendium of State Seed Production agencies, State Agricultural Universities, ICAR Institutes, NGOs and farmers may be established towards awareness about seed production and availability programme. Seed village concept may also be adopted. A National level seed production programme is needed for 5-6 good quality seed varieties suitable for different regions with focus on:

- ❑ Wider dissemination of available best quality seeds along with package of best practices like sowing technologies, after care etc.
- ❑ Seeds of early maturing (85-90 days) and high yielding varieties like, HG 365, HG 563, RGC 936, RGM 112 need to be widely adopted for low rainfall (250 - 400 mm) in poor soil regimes, particularly in parts of Rajasthan, Haryana, Gujarat and other importance states.
- ❑ For moderate rainfall (400 - 500 mm) regions of Rajasthan, Gujarat, Haryana Punjab etc., varieties like: RGC- 1002, RGC- 1003, RGC -1017, and HG 848 etc., need to be popularized and adopted.
- ❑ For higher rainfall (>500 mm) regions and canal command areas, varieties like: RGC 1086, HG 2-20 and RGC 1066 need to be adopted.

4.1.2 Sowing Method:

In view of emerging needs, adequate plant population is a must for high productivity. The planting necessarily be done by seed drills in lines (line sowing) only. Line to line spacing for



spreading (depending on type of variety) may be kept as 60 cm, 45 cm and 35 cm, while plant to plant spacing may be kept as 10 cm only under very low, moderate and high rainfall situations respectively. However, for un-branched varieties, the spacing may be kept respectively as 25 cm and 5 cm. Common practice like broadcasting method of sowing must be completely discouraged.

If planting is effectively taken care of between and within row spacing, there is saving of seeds also along with high yield. Thus, feasible high quality seeds and plants may be made available at the panchayat level in village itself.

4.1.3 Weeding and Inter-culture Operations:

To make the soil moisture and nutrients effectively available to the growing crop under rain-fed conditions and for facilitating better aeration of soil, weeding through mechanical means and / or by hands along with deep inter-culture operations need to be adopted.

4.1.4 Inclusion of non traditional areas and seasons:

For, enhanced area under cultivation of the crop, there is a need to survey areas and understand their technological requirements. There is also a need to manage the guar produce to fetch better price. Practically workable mechanisms to be developed to procure the produce and ultimately to establish linkages with of the producer with the suitable guar gum or guar split industries. Guar is now being cultivated in summer season also with about 5 to 6 irrigations. Yields of summer season guar are almost 1.5 to 2 times more than the rain fed guar. Hence, there is also a need to study this type of cropping system.

The institutional capabilities and network of various Departments / Divisions of Agricultural Extension; KVKs in all the districts, and well spread network of States Department of Agriculture need to be brought together for developing synergy in efforts towards dissemination of proven and established technologies. There is need to prioritize location specific technologies. A group of devoted and dedicated organizations / volunteers be involved for this purpose. Guar days or Guar weeks may be observed to highlight/popularize the best practices among farmers. A separate dedicated extension programme for guar may be initiated. Pamphlets and other audio-visual aids may also be used for popularization of best practices.

Expert organizations to be associated for chalking out time bound action plan for implementation are: ICAR, CAZRI, Central and respective State Agricultural Universities and State seed Production agencies.

4.2 R&D Efforts - Setting the trajectory

4.2.1 Needful Breeding

- ❑ Varieties maturing in < 80 days need to be developed for effective adoption in areas prone to unpredictable low rainfall situations. Source of earlyness is available in the species of *C. senegalensis* and *C. sereta*. Crossing with cultivated species is possible but problems have been witnessed during fertilization. Hence, protoplasmic fusion, ovary rescue or other non-traditional approaches may be adopted.
- ❑ Guar varieties having low, moderate and high viscosity (2000-3000 cP, 3000-5000 cP and >5000 cP, respectively) are required. It will be helpful in the development of value added products. Such task may be assigned to a leading R&D Institution in this domain.
- ❑ Seed Varieties also need to be developed having higher gum content (> 35%).

A concrete action plan to be prepared bringing out detailed R&D Road Map with milestones in close association of organizations like: ICAR, CAZRI, HAU, other Central and State Agricultural Universities and State Seed Production agencies.

4.2.2 Processing and Products

- ❑ For increasing the recovery of endosperm from guar seeds from the present extraction level of 28% - 30% to 35% - 37%, advanced extraction technologies to be developed or scouted.
- ❑ Hydration of splits to be enhanced towards achieving a Fann viscosity of around 50. Towards this, appropriate machinery / technology need to be developed.
- ❑ Reducing processing losses mainly in hydration, flaking and grinding operations.

For addressing the above requirements, advanced machines need to be introduced in guar gum industries / units. Production of quality products in reference to viscosity of galactomannan also be undertaken by adopting appropriate technologies.



Detailed action plan for either acquisition of requisite machineries and demonstration or development of appropriate machineries and demonstration in close association with Institutes like: Institute of Post Harvest Technology (IPHT) Ludhiana and Agricultural Engineering Institutions in India like Central Institute of Agricultural Engineering (CIAE), Bhopal, CMERI Durgapur, etc.

4.2.3 High Value Guar Derivatization

With deeper oil and gas wells, the prevailing conditions become more demanding and severe with respect to temperature, pressure and pH. Thus the stability of guar gum at such conditions becomes critical. R&D Efforts need to be focussed on development of such stable derivatives of guar gum which have enhanced solubility in aqueous solution and hydration besides retention of viscosity at high temperature (150-200 OC and beyond), pH (8-10) & pressure (10-15,000 psi) along with low residue and higher viscosity at similar concentrations.

To meet the above requirements and in view of the present and rapidly emerging oil and gas sector requirements, steps need to be undertaken towards development of high value guar derivatives like double derivative - Carboxy Methyl Hydroxy Propyl Guar (CMHPG) and single derivative - namely Carboxy Methyl Guar (CMG) and Hydroxy Propyl Guar (HPG) in our country.

Organizations like IICT Hyderabad, NCL Pune, ICT Mumbai, Chemical Engineering Department of Calcutta University, FRI Dehradun need to be brought on a common platform for chalking out a comprehensive R&D Strategy.

4.2.4 Alternate Applications

Looking at the current scenario especially the prevailing volatile market conditions, efforts need to be undertaken to widen the market base by developing other value added uses of guar products in different industrial sectors (road construction, personal health care, dietary uses etc).

Organizations like IICT Hyderabad, NCL Pune, ICT Mumbai, Chemical Engineering Department of Calcutta University, FRI Dehradun need to be brought on a common platform for chalking out a comprehensive action plan.

4.2.5 Improving Quality of Guar Meal

Setting up of By Pass Protein Plant for enhanced utilization of crude protein from existing level and value addition of guar meal like Korma and Churi for ruminants is required. Efforts are also needed to focus on removing residual guar gum from guar meal for better quality, and removing other toxic substances (trypsin, inhibitors, saponins, lignins, phytate etc).

4.2.6 General issues:

- ❑ **Price Stability:** Even though Guar by way of export is providing maximum foreign currency to India in the agriculture sector, the exports are susceptible to guar price fluctuations. From the commercial angle, such huge swings of growth and de-growth are very detrimental to the industries and the global reputation of guar gum industry. Price fluctuations of guar are a major concern to the Guar gum industries. Thus price stability of guar needs to be ensured through an appropriate mechanism either through contract farming or reviewing the existing policy and introducing suitable legislation.

In this regard, SHEFEXIL has strongly recommended immediate delisting of Guar Gum from Commodity Exchanges for enhancing real market forces to determine its prices and not speculative forces. SHEFEXIL is also of the view that such a step would nurture the product for export markets, and protect both our farmers and the export earnings.

- ❑ **NCDEX:** Thus, NCDEX needs to be reviewed to avoid price speculation.
- ❑ **Taxations:** This is the crop of poor men, hence applicability of Mandi tax, State Taxation Policy etc may need to be reviewed.
- ❑ **Duty:** China charges 5% and 15% duty from Indian guar splits and guar powder, respectively but not on guar exports from Pakistan. This issue needs to be addressed at an appropriate level.
- ❑ **Single Window System:** Guar research, trading, industries export etc., may be brought under single window system.
- ❑ **Policy** may be formulated for keeping the prices of guar stable, reasonable and stable for sustained growth of this sector.



- ❑ **Market Information System (MIS):** Market related information including projected requirements need to flow between all the stakeholders and for this an appropriate web based platform may be put in place.

Appropriate Policy initiatives for addressing the above, need to be drawn up by Ministry of Commerce and in consultation with organizations like NIAM.

4.2.7 Energy Audits:

There is a need for a thorough energy audit of the entire industrial processes.

4.8 Creation/Strengthening of R&D Infrastructure

5.0 MISSION MODE APPROACH

On overview, it is felt that there is a huge latent and untapped potential of guar gum and its various derivatives

which need to be exploited and utilized. This requires an aggregate view of the entire value chain and composite actions spanning from crop cultivation, processing to finished products, exploring new applications and developing by products besides initiatives on the policy front. Though various domain specific organizations are working in different areas, it may be worthwhile to approach and address the broad spectrum of issues under an Umbrella of Mission Mode Program which can steer and orchestrate beginning to end linking and networking of various stakeholders involved and nucleate & execute requisite specific actions through individual domain organizations.

TIFAC with its vast experience in networking and coordinating with a wide spectrum of stakeholders, including inter ministerial organizations and also with the accrued experience of executing several major Technology programs in Mission Mode, could play a leading role in this context.





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...and many others.

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&
Shri Rahul Kumar, Scientist D





Country Wise Export Statement of Guar Gum from India

(Valu in Rs. Lakh)

Importing Country	2007-08		2008-09		2009-10		2010-11		2011-12		2012-13		2013-14	
	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value
GUAR GUM REFINED SPLIT														
Albania	0.00	0.00	15.00	9.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Argentina	0.00	0.00	20.00	10.51	39.39	23.27	90.44	58.47	0.00	0.00	18.00	176.44	36.36	60.02
Australia	248.58	153.18	254.00	116.18	68.85	48.13	52.00	37.69	0.00	0.00	0.00	0.00	1.70	8.62
Austria	0.00	0.00	0.00	0.00	0.00	0.00	36.00	35.48	0.00	0.00	0.00	0.00	0.00	0.00
Baharain	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.84	0.00	0.00	0.10	0.59
Bangladesh	0.00	0.00	2.00	0.93	0.00	0.00	40.00	6.17	0.00	0.00	0.84	0.96	0.00	0.00
Belgium	367.46	180.61	370.00	162.32	216.50	143.61	60.00	45.51	160.00	278.34	280.00	945.73	340.00	581.42
Brazil	260.48	137.25	100.00	62.00	150.90	120.77	154.86	105.83	0.00	0.00	0.00	0.00	50.00	116.40
Bulgaria	5.20	2.94	6.00	3.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canada	151.68	97.92	0.00	0.00	57.04	22.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chile	80.00	42.94	0.00	0.00	0.00	0.00	22.20	13.68	0.00	0.00	22.00	123.15	0.00	0.00
China	23339.12	10086.82	27297.99	11453.39	12231.39	5225.73	22770.99	13547.39	40645.81	81747.77	27578.00	120762.87	47435.20	81472.12
Colombia	20.00	10.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Congo, D.R.	0.00	0.00	4.13	3.73	0.05	0.14	0.10	0.13	7.57	4.82	0.00	0.00	0.20	1.30
Cote d'Ivoire (Ivory Coast)	3.00	2.70	19.74	7.51	0.00	0.00	0.00	0.00	0.00	0.00	12.70	9.53	0.00	0.00
Czech Republic	0.00	0.00	0.00	0.00	20.10	11.62	20.00	11.86	40.00	53.68	0.00	0.00	0.00	0.00
Denmark	20.00	10.55	20.00	9.38	20.20	12.83	93.80	78.57	0.00	0.00	0.00	0.00	0.00	0.00
Djibouti	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
Ecuador	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
Egypt	10.00	5.11	0.00	0.00	1.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
France	60.42	29.80	60.00	28.35	18.00	6.94	10.00	6.38	0.00	0.00	0.00	0.00	0.00	0.00
Germany	738.76	360.71	895.01	411.73	392.29	281.88	912.62	562.68	241.00	330.49	140.00	437.14	20.00	63.60
Ghana	13.20	9.31	0.00	0.00	0.00	0.00	100.00	52.24	0.00	0.00	0.26	1.01	0.00	0.00
Greece	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
Guatemala	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
Hong Kong	40.00	21.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.06
Hungary	0.00	0.00	20.00	12.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Indonesia	37.22	16.19	60.00	33.45	20.00	11.13	148.85	101.00	0.00	0.00	3.00	5.98	100.00	268.81
Iran	40.00	20.48	42.30	15.98	18.25	13.69	20.00	12.37	20.27	44.42	0.00	0.00	0.00	0.00
Israel	0.00	0.00	37.00	11.53	40.45	23.98	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.54
Italy	176.20	98.67	177.00	86.49	16.27	7.07	1367.01	338.07	872.80	1383.64	20.00	37.67	0.00	0.00
Japan	48.00	23.11	20.01	10.92	25.92	99.78	195.16	301.31	0.00	0.00	0.00	0.00	0.13	0.30
Jordan	51.00	28.45	0.00	0.00	0.00	0.00	0.00	0.00	9.45	10.64	0.00	0.00	4.00	13.25
Kenya	0.10	0.05	6.85	3.47	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.79
Kuwait	0.00		0.00	0.00	0.00	0.00	0.00	0.00	6.10	5.80	0.95	1.23	5.63	15.54
Korea DP R	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.39	0.00	0.00	0.00	0.00
Korea Republic (South)	53.57	29.36	18.10	9.48	32.69	17.64	73.64	43.14	0.50	1.51	0.00	0.00	0.00	0.00
Lebanon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	9.91
Lithuania	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	20.00	102.98	6.00	10.58
Malagasy (Mada-gascar)	0.00	0.00	0.45	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malaysia	69.96	35.67	0.00	0.00	5.00	3.73	136.05	65.17	10.00	10.21	0.00	0.00	0.00	0.00
Mauritius	0.00		0.00		0.00	0.00	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Mexico	68.00	39.59	40.00	21.46	40.24	25.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nepal	23.31	6.31	24.55	8.27	38.13	15.01	4.20	2.74	15.39	17.14	0.00	0.00	5.03	7.58



**GUAR STATUS, POTENTIAL, PROSPECTS,
CHALLENGES AND R&D ROAD MAP**

(Valu in Rs. Lakh)

Importing Country	2007-08		2008-09		2009-10		2010-11		2011-12		2012-13		2013-14	
	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value						
Netherlands	2026.17	975.35	1376.52	707.00	1425.52	736.29	1777.57	935.70	2657.30	3926.21	400.00	2183.09	900.00	1880.68
New Caledinia	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	100.00	272.82	0.00	0.00
New Zealand	100.80	46.50	0.00	0.00	17.50	10.90	0.00	0.00	3.50	2.67	0.00	0.00	1.00	3.25
Nigeria	0.00	0.00	2.01	1.45	0.00	0.00	10.24	1.91	0.50	0.66	0.00	0.00	0.00	0.00
Norway	20.00	8.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oman	18.04	9.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pakistan	60.00	26.85	100.00	45.65	1085.41	473.21	2255.97	1139.11	1010.00	1631.53	160.00	538.35	80.00	169.99
Peru	2.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	4.69
Philippines	160.20	84.84	40.00	23.47	0.00	0.00	26.00	25.64	0.00	0.00	0.00	0.00	0.00	0.00
Poland	60.00	30.21	20.00	10.98	20.10	12.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Russia	46.30	31.99	90.00	42.19	100.03	39.49	1062.53	1024.09	36.00	41.88	36.00	264.58	0.00	0.00
Saudi Arabia	24.19	11.60	65.51	26.64	14.41	7.67	20.83	6.79	12.73	11.81	5.11	7.46	0.60	1.27
South Africa	4861.78	2179.96	2330.48	1067.85	600.00	310.81	5145.44	2761.63	3140.00	3746.62	320.00	469.34	40.00	101.03
Spain	588.00	268.50	327.00	133.44	280.26	131.48	180.00	78.93	400.00	817.17	141.00	441.25	80.00	136.40
Sri Lanka	2.49	1.46	0.00	0.00	0.03	0.00	25.88	2.40	0.00	0.00	3.20	6.72	2.51	8.25
Sudan											0.00	0.00	0.06	0.15
Swaziland	36.00	8.05	0.00	0.00	0.00	0.00	0.00	0.00	220.10	396.95	0.00	0.00	20.00	63.62
Switzerland	247.50	115.35	35.00	28.88	42.00	20.91	470.43	489.13	1232.14	4100.29	1160.00	9183.55	1140.00	2329.90
Taiwan (Taipei)	105.00	47.25	40.00	17.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thailand	298.10	144.81	58.90	32.01	31.72	16.93	25.00	13.36	3.00	10.35	0.00	0.00	4.00	13.67
Turkey	114.52	60.94	6.00	2.25	0.00	0.00	0.00	0.00	17.00	18.88	0.00	0.00	322.00	65.57
U.A.E	433.00	186.65	88.00	38.75	16.00	11.91	20.00	12.72	100.20	70.79	0.20	0.97	1.42	2.84
UK	505.41	327.70	210.80	95.08	345.69	172.56	116.20	72.44	272.00	436.19	70.00	118.64	120.01	186.19
Unknown	122.50	51.95	160.00	70.87	430.00	178.07	164.66	138.33	0.00	0.00	0.00	0.00	0.00	0.00
USA	27931.10	14126.00	20972.72	10162.96	14275.71	7418.55	40868.79	25578.25	51289.89	93228.35	40023.91	202961.17	31964.58	60798.85
Uganda	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.81	0.00	0.00
Viet Nam	20.00	9.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yemen	3.00	1.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	8.99
Zambia	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.35	0.00	0.00
TOTAL	63711.35	30206.76	55433.05	24999.17	32137.06	15656.10	78477.47	47706.35	102423.74	192330.04	70515.24	339053.79	82689.08	148408.77

GUAR MEAL

Australia	0.86	0.67	0.00	0.00	0.00	0.00	40.20	29.77	0.00	0.00	0.00	0.00	1.00	0.47
Bangladesh	0.00	0.00	10.00	6.21	245.00	38.22	88.00	13.32	0.00	0.00	231.00	44.01	743.00	135.63
Belgium	0.00	0.00	0.00	0.00	23.00	2.82	0.00	0.00	0.00	0.00	0.00	0.00	930.00	288.88
Bulgaria	0.00		0.00		0.00	0.00	2.50	0.55	0.00	0.00	0.00	0.00	1500.00	519.66
Chile	0.00	0.00	40.00	4.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.00	14.43
China	160.00	50.30	466.90	63.21	347.00	44.09	1280.42	265.07	9975.00	1904.12	678.00	387.52	2136.00	736.36
Colombia											0.00	0.00	22.30	6.42
Cook Islands	0.00	0.00	0.00	0.00	20.00	5.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cyprus	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	20.00	3.56	898.00	200.04
Denmark											0.00	0.00	600.00	214.92
Ecuador	0.00	0.00	616.00	81.11	0.00	0.00	630.00	90.46	3225.00	504.93	1302.00	268.70	1120.00	238.11
Egypt	10.00	2.20	0.00	0.00	0.00	0.00	419.20	67.50	4947.00	708.96	10060.80	1724.90	28434.00	5956.08
Franc	0.00		0.00		0.00	0.00	0.00	0.00	30.00	7.48	20.00	3.52	438.00	87.42
Georgia	0.00	0.00	10.00	4.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	44.00	8.75
Germany	25.80	62.56	20.00	10.71	1709.00	297.51	522.20	102.92	313.00	75.03	270.00	44.86	1102.00	283.22
Greece	0.00	0.00	240.00	29.89	480.00	84.18	660.36	130.54	4204.90	943.65	6118.00	1502.25	7945.00	2449.06
Hong Kong	0.00	0.00	21.00	3.20	0.00	0.00	1.40	0.90	600.00	74.97	660.00	99.33	0.00	0.00



(Valu in Rs. Lakh)

Importing Country	2007-08		2008-09		2009-10		2010-11		2011-12		2012-13		2013-14	
	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value
Hungary	0.00		0.00		0.00	0.00	21.80	5.70	0.00	0.00	0.00	0.00	0.00	0.00
Indonesia	0.00	0.00	0.00	0.00	304.00	50.70	228.00	34.33	4738.80	488.80	12429.00	1897.93	10472.00	1563.66
Iran	4.00	2.24	5567.41	819.63	2916.58	594.36	170.00	24.42	696.00	78.94	0.00	0.00	60.00	10.85
Iraq	4.00	2.24	471.00	88.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Israel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	2.66	266.00	59.74	0.00	0.00
Italy	0.15	0.18	1080.40	143.19	3494.68	597.35	7281.74	1650.84	9437.52	1647.17	7732.10	1778.50	15974.20	3858.17
Japan	0.00	0.00	0.00	0.00	0.00	0.00	60.26	26.88	80.00	7.78	0.11	0.05	1261.09	222.60
Jordan	17.00	2.44	728.00	98.70	110.00	17.34	20.00	2.29	0.00	0.00	0.00	0.00	63.00	14.39
Korea Republic (South)	33.50	37.82	1105.22	144.44	7.00	6.12	0.00	0.00	0.00	0.00	191.00	28.35	3211.00	522.02
Latvia	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	6128.00	1546.16	9844.00	2406.94
Lebanon	10.00	2.01	56.00	5.55	112.00	15.45	225.00	29.45	230.00	19.93	40.00	11.78	370.00	59.45
Liechtenstein											0.00	0.00	120.00	34.94
Lithuania	0.00	0.00	20.00	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3255.00	828.01
Macedonia											0.00	0.00	20.00	5.01
Madagascar											0.00	0.00	21.00	4.12
Malaysia	4002.00	555.82	9230.30	1006.58	7650.00	934.47	8153.32	1005.71	17139.00	1788.35	11505.00	1567.74	11743.00	1674.61
Malta											0.00	0.00	40.00	9.69
Myanmar											0.00	0.00	40.00	8.38
Maldives	0.00	0.00	0.09	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mexico	0.00	0.00	11.00	10.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Morocco	0.00		0.00		0.00	0.00	0.00	0.00	540.00	59.74	0.00	0.00	0.00	0.00
Namibia	0.00	0.00	20.09	2.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nepal	1.85	0.36	15.20	1.77	0.94	0.33	1.30	0.23	2.08	1.09	0.00	0.00	25.00	6.22
Netherlands	16.50	33.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
New Zealand	0.00	0.00	249.00	36.06	0.00	0.00	0.00	0.00	0.00	0.00	20.00	3.64	40.00	10.28
Nigeria											0.00	0.00	0.10	0.64
Norway	0.00		0.00		0.00	0.00	120.00	17.97	0.00		0.00	0.00	0.00	0.00
Oman	0.00	0.00	60.00	5.22	0.00	0.00	665.59	125.73	1519.00	198.65	632.00	95.76	112.00	24.41
Pakistan	0.00	0.00	0.00	0.00	45.00	8.98	0.00	0.00	0.00	0.00	0.00	0.00	20.00	4.09
Philippines	0.00	0.00	301.00	47.07	3938.04	584.03	3515.00	486.92	4067.90	434.05	3238.00	601.80	2589.00	597.75
Poland	0.00	0.00	1.00	0.15	40.00	6.05	0.00	0.00	3489.94	715.86	1183.00	272.31	4071.00	1007.12
Portugal	0.00		0.00		0.00	0.00	0.00	0.00	120.00	16.42	0.00	0.00	0.00	0.00
Qatar	0.00	0.00	20.00	2.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Romania											0.00	0.00	20.00	5.74
Russia	50.34	20.74	37.00	28.40	0.00	0.00	0.00	0.00	20.00	4.00	20.00	6.23	0.00	0.00
Saudi Arabia	0.00	0.00	0.00	0.00	23.00	2.69	1.00	0.10	105.00	14.33	10.02	1.67	0.00	0.00
Singapore	0.40	0.07	300.00	40.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Slovenia											0.00	0.00	20.00	6.69
South Africa	0.00		0.00		0.00	0.00	0.50	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Spain											0.00	0.00	44.00	14.47
Sri Lanka	0.00	0.00	0.00	0.00	0.00	0.00	20.67	2.31	0.00	0.00	4011.00	880.25	7601.00	1606.64
Syria	23.00	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Switzerland	0.00		0.00		0.00	0.00	30.00	22.80	0.00	0.00	0.00	0.00	0.00	0.00
Taiwan (Taipei)	0.00	0.00	40.00	6.23	692.00	88.50	736.00	93.34	155.00	19.83	2310.00	342.62	4611.00	744.99
Thailand	9.00	9.28	20.00	2.17	822.00	114.07	750.45	113.52	465.00	48.41	675.00	112.95	1788.00	343.28
Turkey	0.00	0.00	792.00	95.17	10030.00	1697.62	12706.20	1742.92	12839.27	1549.40	4503.00	613.77	7327.00	1568.57
U.A.E	0.00	0.00	302.00	34.21	1.35	0.57	100.00	9.65	540.00	73.54	2.40	0.88	420.00	98.34



GUAR STATUS, POTENTIAL, PROSPECTS, CHALLENGES AND R&D ROAD MAP

(Valu in Rs. Lakh)

Importing Country	2007-08		2008-09		2009-10		2010-11		2011-12		2012-13		2013-14	
	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value
UK	0.00	0.00	24.50	2.18	61.48	9.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown	0.00	0.00	0.00	0.00	594.00	100.37	306.00	45.43	0.00	0.00	0.00	0.00	0.00	0.00
USA	12.00	6.82	309.22	188.20	10.55	16.38	235.70	167.15	650.88	294.35	123.70	27.27	720.17	558.40
Viet Nam	2639.00	531.88	10061.00	1221.57	7808.00	1051.45	0.00	0.00	0.00	0.00	435.00	99.83	235.00	33.87
Yemen	9.70	5.40	23.00	3.23	90.00	12.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	7029.10	1329.44	32268.24	4243.03	41574.61	6381.01	38992.80	6308.88	80150.29	11682.44	74814.14	14027.88	132110.86	28993.79

GUARGUM TREATED & PULVERISED

Afghanistan	52.00	30.70	21.00	11.63	18.00	8.13	42.00	25.01	0.00	0.00	0.00	0.00	90.01	341.47
Albania	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.00	12.90	0.00	0.00	5.00	15.75
Algeria	200.10	111.01	140.00	76.03	60.00	36.75	120.30	80.83	20.00	22.37	50.00	160.44	90.00	215.34
Angola	2.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	40.00	92.73	0.00	0.00	0.00	0.00
Argentina	1194.26	624.65	1494.43	850.60	849.03	500.17	1482.99	1153.66	1440.12	2299.48	334.00	1311.25	2291.88	5991.78
Australia	3609.24	1790.35	6280.38	3186.23	3970.63	2085.61	4431.93	2902.18	9380.84	25319.10	3959.35	22708.07	1719.00	4127.09
Austria	80.00	36.84	18.15	22.06	5.00	2.92	36.23	21.72	27.00	51.23	0.00	0.00	0.00	0.00
Bahrain	22.04	13.24	26.00	15.83	4.00	4.12	2.00	2.00	4.30	6.27	0.00	0.00	4.60	18.26
Bangladesh	95.51	54.75	177.05	126.00	209.00	138.06	133.13	91.79	18.00	8.99	0.00	0.00	5.03	12.77
Barbados	0.00	0.00	2.00	1.48	2.00	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Belarus	0.00	0.00	20.00	10.24	20.10	11.77	20.00	20.32	82.30	177.70	20.00	58.73	50.00	113.82
Belgium	2122.06	1300.38	2905.08	1664.62	1451.50	1149.39	1957.94	1615.74	3485.48	6457.55	222.13	780.83	782.00	1745.44
Benin	320.00	179.82	400.00	252.70	220.00	147.69	400.00	244.67	600.00	1618.41	40.00	256.08	0.00	0.00
Bhutan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00	3.05	0.00	0.00	0.00	0.00
Bolivia	19.00	10.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bosnia-Herzegovina	0.00	0.00	40.00	22.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brazil	2610.67	1411.09	2697.95	1572.61	3312.01	1937.44	3471.02	2411.31	3758.52	7507.03	2045.74	8089.61	3046.09	8451.81
British Virgin Islands	39.00	19.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Brunei	18.00	10.06	39.10	16.70	40.00	23.80	0.00	0.00	31.00	131.43	0.00	0.00	0.00	0.00
Bulgaria	60.20	31.33	60.00	33.02	102.24	52.19	124.63	92.65	141.35	211.36	30.00	100.72	22.50	56.88
Cambodia (Kampuchea)	0.00	0.00	2.00	0.89	0.00	0.00	5.00	3.74	15.00	31.98	0.00	0.00	0.00	0.00
Cameroon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.25	0.00	0.00	0.00	0.00
Canada	1824.80	1110.48	1791.28	1194.97	1152.14	838.75	4215.70	3234.45	8088.35	22888.97	5466.60	36045.07	8736.38	22132.47
Cayman Islands	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
Chad	18.00	9.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	47.85
Chile	746.99	400.28	924.43	510.06	635.64	356.06	720.33	459.88	1133.34	2165.90	460.00	1601.01	788.05	1691.49
China	10799.87	5671.56	11460.87	6188.00	12683.10	6930.60	10700.23	6870.81	7409.70	13342.25	4012.43	15682.55	7396.98	14580.89
Christmas Island	0.00	0.00	0.00	0.00	0.00	0.00	20.22	12.11	0.00	0.00	0.00	0.00	0.00	0.00
Cocos Islands	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
Colombia	239.98	130.38	186.80	106.02	207.75	125.29	300.85	188.59	222.77	351.16	140.00	535.50	197.13	449.60
Comoros	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
Congo Rep	0.00	0.00	0.00	0.00	3.00	2.56	0.00	0.00	0.10	0.28	31.04	48.19	15.00	53.91
Congo D.Rep	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
Costa Rica	43.00	23.43	20.00	12.02	40.00	21.16	40.00	24.24	20.00	20.11	10.00	37.66	12.00	27.31
Cote d'Ivoire (Ivory Coast)	0.00	0.00	0.00	0.00	0.00	0.00	40.24	26.76	0.00	0.00	0.00	0.00	0.00	0.00
Croatia	20.00	10.20	0.00	0.00	12.00	5.47	56.05	41.87	0.00	0.00	0.00	0.00	23.00	44.43
Czech Republic	40.00	19.71	62.00	32.75	18.00	9.90	360.52	271.14	226.37	375.02	40.00	106.03	98.00	155.66
Denmark	1615.90	858.26	1590.00	865.83	1701.61	931.23	2033.98	1337.35	2218.78	3711.96	1196.54	6222.69	752.28	1977.15
Djibouti	0.00	0.00	0.00	0.00	55.00	27.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dominican Republic	32.99	19.00	0.00	0.00	40.00	21.88	40.00	24.10	0.00	0.00	17.00	58.12	25.00	63.25
Ecuador	147.00	84.56	56.00	28.22	32.00	17.69	62.00	42.04	14.00	25.60	5.00	13.45	49.03	99.06



(Value in Rs. Lakh)

Importing Country	2007-08		2008-09		2009-10		2010-11		2011-12		2012-13		2013-14	
	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value
Egypt	1104.88	661.52	1028.53	737.52	920.32	663.20	1064.46	978.13	1020.93	1814.52	196.00	748.76	1020.03	1302.49
El Salvador	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
Estonia											0.00	0.00	18.00	29.03
Falkland Islands (Malvinas)	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
Fiji	0.00		0.00		0.00		21.00	13.68	2.00	2.76	0.00	0.00	0.00	0.00
Finland	63.00	34.82	53.00	32.88	71.00	43.35	105.05	72.85	35.00	53.09	31.00	115.47	100.00	212.31
France	977.03	567.94	1432.07	973.63	2854.91	2215.42	2390.16	1517.78	1965.51	3660.33	572.30	1856.74	685.05	1423.01
Gambia	18.00	8.97	0.00	0.00	0.00	0.00	78.00	39.88	0.00	0.00	0.00	0.00	1.20	1.59
Germany	17135.12	9305.82	21594.02	11851.99	18497.63	9836.09	28451.47	16648.35	34543.80	65217.66	11674.87	37067.01	15834.65	32875.30
Ghana	0.00	0.00	15.15	7.44	0.00	0.00	115.00	71.12	50.28	164.47	0.30	3.40	4.40	6.49
Greece	209.92	110.06	157.84	87.31	75.00	41.72	110.15	89.19	358.87	344.79	144.47	91.49	318.00	275.10
Grenada	0.00		0.00		0.00		45.00	21.27	0.00	0.00	0.00	0.00	0.00	0.00
Guatemala	405.77	221.23	307.16	184.53	268.16	161.48	375.89	261.78	309.16	570.88	123.00	388.83	148.04	324.96
Haiti	0.00	0.00	43.30	37.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Honduras	20.00	10.61	20.00	11.77	40.00	22.88	60.00	39.70	40.00	67.12	0.00	0.00	0.00	0.00
Hong Kong	1254.34	642.80	653.88	342.42	146.74	79.04	65.51	37.78	101.04	184.88	20.03	112.48	19.00	55.88
Hungary	60.00	30.19	84.00	46.84	20.24	9.37	80.00	48.52	0.00	0.00	0.00	0.00	20.00	34.69
Indonesia	1716.33	875.97	1718.05	947.96	1816.97	997.31	2921.25	1968.23	3027.64	7334.46	1998.00	9469.54	2109.17	4978.58
Iran	1082.00	577.33	1298.99	624.27	1447.35	791.39	1472.42	930.20	668.69	1322.64	296.00	980.30	1067.70	2883.56
Iraq	39.64	20.26	59.80	32.54	220.00	121.57	40.00	22.19	0.00	0.00	20.70	80.58	50.00	77.82
Ireland	7.08	6.57	22.00	11.82	40.00	22.56	0.00	0.00	0.30	1.08	0.00	0.00	0.00	0.00
Israel	888.92	439.80	689.00	366.11	377.98	172.48	1031.74	740.51	611.42	1099.82	630.00	2439.39	360.02	670.71
Italy	4720.54	2557.29	4647.57	2494.58	3243.87	2179.67	6626.36	5128.67	12017.36	19806.05	4899.20	16139.64	5322.75	12594.13
Jamaica	0.00	0.00	8.80	6.44	0.00	0.00	2.00	1.72	5.50	11.06	0.00	0.00	0.00	0.00
Japan	2394.71	1567.28	1787.83	949.52	1862.72	1882.88	2423.76	2236.55	2123.08	5313.37	1027.38	5568.73	1580.95	5510.86
Jordan	283.07	144.06	291.00	144.14	297.55	160.04	229.75	152.13	254.00	336.65	197.25	675.99	317.45	731.79
Kazakhstan	100.00	64.65	100.32	69.34	160.00	122.30	0.10	0.26	83.20	152.50	13.80	25.61	80.00	145.82
Kenya	23.24	4.72	90.13	71.70	35.44	22.03	47.89	42.64	32.25	60.29	53.95	51.62	2.60	10.92
Kiribati	0.00	0.00	6.00	3.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Korea DPR (North)	121.60	69.00	53.00	34.14	62.10	36.57	170.83	119.39	129.77	291.80	88.83	385.38	116.01	256.49
Korea Republic (South)	1435.54	953.02	1392.91	750.49	1547.12	1116.26	1736.03	1401.60	1783.47	3955.83	564.28	1946.40	908.99	2020.57
Kuwait	20.25	10.99	40.20	18.58	40.00	24.51	1.00	0.92	5.00	21.09	5.00	11.39	0.30	1.14
Latvia	40.00	20.03	40.00	19.77	0.00	0.00	0.00	0.00	0.00	0.00	15.00	56.47	1061.60	1985.01
Lebanon	20.00	12.01	74.50	69.65	0.00	0.00	15.00	8.14	0.00	0.00	10.00	38.37	20.00	47.64
Libya	10.00	5.35	64.00	43.81	62.00	39.23	125.94	96.37	0.00	0.00	0.00	0.00	0.00	0.00
Lithuania	16.00	9.31	0.00	0.00	20.00	12.84	119.09	138.74	100.26	270.57	45.00	134.45	177.00	134.65
Macedonia	0.00		0.00		0.00	0.00	54.00	42.63	0.00	0.00	0.00	0.00	0.00	0.00
Malagasy (Madagascar)	0.00	0.00	22.81	18.38	0.00	0.00	0.00	0.00	0.20	0.31	0.00	0.00	0.00	0.00
Malaysia	2090.33	693.53	576.05	313.76	548.59	291.49	1067.53	718.26	2042.93	5273.45	597.58	2296.76	1170.39	2285.37
Mali	0.00		0.00		0.00	0.00	0.00	0.00	20.00	73.84	0.00	0.00	31.07	44.23
Malta	8.00	3.92	27.00	13.95	7.00	3.46	10.00	5.58	9.90	11.73	0.00	0.00	0.00	0.00
Martinique	0.00	0.00	0.00	0.00	20.24	10.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mauritania	0.00	0.00	21.00	10.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mauritius	1.50	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mexico	1181.70	568.36	1594.70	886.06	1588.91	897.57	2075.82	1355.96	2245.56	3577.41	1342.20	4404.84	1376.40	2893.73
Mongolia	0.00	0.00	15.00	7.85	0.00	0.00	14.00	15.66	0.00	0.00	20.00	149.92	10.00	29.00
Morocco	49.87	20.51	56.06	31.29	40.00	21.81	80.80	54.83	23.00	53.39	40.00	130.98	78.10	120.92
Mozambique	0.00		0.00		0.00	0.00	0.00	0.00	64.00	138.94	0.00	0.00	9.50	18.24
Myanmar (Burma)	3.25	2.14	0.00	0.00	0.10	0.17	0.00	0.00	0.00	0.00	0.20	0.80	15.00	35.57
Nepal	80.00	34.41	79.04	28.09	56.42	22.07	100.87	45.68	68.73	125.89	1.46	11.96	0.37	1.08
Netherlands	2396.80	1674.36	2485.72	1349.37	1936.18	1668.60	3263.74	2796.38	7167.57	15506.91	3244.37	13843.55	2831.58	6769.31
Netherlands Antilles	0.00	0.00	0.00	0.00	0.00	0.00	49.00	45.30	0.00	0.00	0.00	0.00	0.00	0.00



**GUAR STATUS, POTENTIAL, PROSPECTS,
CHALLENGES AND R&D ROAD MAP**

(Valu in Rs. Lakh)

Importing Country	2007-08		2008-09		2009-10		2010-11		2011-12		2012-13		2013-14	
	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value	Qty (M/T)	Value
New Zealand	159.00	86.44	204.77	108.34	133.29	76.43	46.12	35.95	222.69	624.24	136.80	573.37	100.71	294.88
Nigeria	38.00	21.98	104.11	59.26	132.38	114.47	35.50	24.71	93.20	160.53	85.50	506.55	165.95	433.14
Norway	65.00	34.34	0.00	0.00	66.00	40.97	34.00	23.23	51.00	68.26	0.00	0.00	9.00	17.10
Oman	47.76	27.23	100.38	75.17	56.00	18.27	52.40	39.24	37.00	27.96	5.00	27.50	151.00	445.43
Pakistan	18.04	11.55	0.10	0.07	280.42	130.84	78.00	42.11	122.00	106.40	0.00	0.00	0.00	0.00
Panama	0.00	0.00	32.00	18.03	30.00	18.87	20.00	11.31	17.00	33.01	22.00	75.30	0.00	0.00
Panama Central Zone	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
Panama Republic											0.00	0.00	35.04	73.46
Paraguay	0.00	0.00	1.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Peru	177.30	101.77	129.00	82.79	108.00	58.19	230.91	174.98	253.00	480.29	94.00	470.55	114.01	208.00
Philippines	335.09	177.41	546.20	268.41	454.52	252.93	574.72	398.50	612.77	1046.91	224.05	1092.76	329.00	786.30
Poland	756.21	388.47	818.71	417.72	886.71	438.28	1402.76	964.50	2121.44	3068.71	373.28	1392.51	684.00	1352.40
Portugal	0.00		0.00		0.00	0.00	52.66	27.46	20.00	26.37	0.00	0.00	9.00	18.93
Qatar	149.88	83.40	93.00	46.92	147.53	74.60	40.00	26.38	20.00	18.89	0.00	0.00	0.00	0.00
Romania	34.00	18.73	25.00	23.97	80.00	59.32	143.46	120.16	134.00	307.64	22.30	173.55	41.00	92.87
Russia	3708.45	1930.07	6565.98	4105.09	6000.96	3875.45	12983.19	10798.99	10990.88	30688.49	5332.80	28940.87	10970.50	30067.14
Saudi Arabia	727.41	480.21	1046.09	551.33	549.68	441.17	544.91	437.52	482.81	816.85	249.10	1255.99	263.00	936.24
Senegal	0.00		0.00		0.00	0.00	40.00	28.28	5.00	1.87	20.00	165.63	9.00	14.87
Sierra Leone	0.00	0.00	0.00	0.00	20.00	11.30	0.00	0.00	59.76	116.56	0.00	0.00	0.00	0.00
Singapore	199.06	110.27	166.64	95.98	203.91	113.56	130.50	105.23	111.55	228.16	27.65	111.06	570.94	1996.04
Slovakia	0.00	0.00	5.00	4.84	0.00	0.00	67.12	80.36	0.00	0.00	0.00	0.00	0.00	0.00
Slovenia	20.84	9.54	45.00	22.91	40.00	22.98	80.00	45.93	20.00	22.23	0.00	0.00	78.00	127.35
South Africa	4082.63	2029.43	2035.18	1039.20	2477.28	1336.02	2422.17	1603.42	2661.58	6054.75	1061.00	3910.96	1553.00	3281.70
Spain	1193.94	645.99	1052.76	581.87	962.27	515.99	2241.06	1414.27	1070.36	2238.51	603.00	2416.22	574.25	1082.04
Sri Lanka	84.94	59.60	88.37	60.04	175.62	113.53	75.67	58.35	122.27	232.77	23.30	79.80	23.01	72.47
Sudan	79.76	41.86	0.00	0.00	0.00	0.00	0.05	0.04	0.43	0.09	0.03	0.37	0.00	0.00
Swaziland	40.00	20.23	0.00	0.00	0.00	0.00	0.00	0.00	144.20	251.32	0.00	0.00	0.00	0.00
Sweden	0.00	0.00	0.00	0.00	24.00	25.17	95.81	121.46	125.02	302.99	171.36	631.56	51.00	160.82
Switzerland	1223.35	668.44	520.28	262.14	475.66	259.54	589.45	346.54	1051.83	2591.62	240.00	790.33	481.00	1073.43
Syria	398.18	203.15	82.20	37.81	384.99	197.87	122.00	71.28	185.78	306.13	88.50	306.11	238.00	577.83
Taiwan (Taipei)	616.58	360.01	838.68	496.54	687.26	452.53	661.28	508.46	483.00	648.76	318.74	599.49	368.69	657.04
Tanzania	21.00	18.49	73.75	75.17	250.10	254.66	141.10	137.36	166.67	207.98	7.10	16.88	13.70	33.75
Thailand	1107.64	561.82	1156.89	454.75	1426.13	714.88	1696.86	1160.96	1956.99	5595.06	727.34	3683.13	929.97	2122.33
Trinidad and Tobago	0.00	0.00	1.20	0.98	1.20	1.22	0.00	0.00	6.00	8.13	0.00	0.00	0.00	0.00
Tunisia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.00	29.86	0.00	0.00
Turkey	974.98	569.07	682.91	397.26	671.58	414.92	1264.81	865.49	508.59	946.22	500.45	1714.27	1007.84	2254.79
Turkmenistan	2.00	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25	14.74
U.A.E	1397.45	636.74	541.11	325.95	305.49	156.91	1235.61	951.22	2654.02	4014.27	354.33	1754.69	1879.22	5055.65
Uganda	0.00	0.00	0.34	0.10	56.00	22.73	0.00	0.00	0.00	0.00	0.15	1.46	0.00	0.00
UK	2042.42	1061.61	3285.92	1743.06	2995.38	1576.56	4586.15	3142.96	5944.97	11193.93	1534.73	5397.25	3091.46	6335.86
Ukraine	277.29	143.49	532.00	306.66	370.90	219.04	733.27	477.59	214.00	339.51	30.00	102.37	281.00	626.94
Unspecified	98.00	51.34	234.00	138.51	1050.56	547.45	1053.14	644.56	18.00	16.94	4.50	27.93	10.00	15.76
Uruguay	36.17	19.60	40.00	21.81	34.00	18.38	45.03	29.74	88.00	160.13	52.00	172.64	77.00	184.34
USA	53831.46	34282.18	75867.34	51953.75	57636.60	39409.59	164789.45	142848.89	382313.30	1151080.15	202455.75	1525176.77	299580.78	791601.43
Uzbekistan	0.00	0.00	65.53	48.58	0.00	0.00	40.30	28.12	0.00	0.00	0.00	0.00	0.00	0.00
Venezuela	114.20	60.69	168.00	89.72	93.25	45.52	75.40	72.56	0.00	0.00	12.00	72.80	30.00	122.93
Viet Nam	394.48	210.91	506.89	229.28	252.93	149.68	320.35	200.64	337.88	671.70	163.70	659.32	262.02	595.26
Yemen	26.60	20.11	65.00	39.28	79.23	36.28	1.66	3.16	7.00	17.23	58.25	195.32	69.00	147.45
Zambia	0.00	0.00	80.00	40.54	0.00	0.00	0.00	0.00	0.00	0.00	2.67	1.44	2.00	4.29
Zimbabwe	0.00		0.00		0.00	0.00	0.00	0.00	0.00	0.00	20.00	49.15	20.00	50.27
TOTAL	140430.12	81038.33	170866.27	104656.33	144768.07	91293.45	286204.73	227179.44	524750.76	1448374.22	260982.34	1775618.61	387161.62	996136.74
GRAND TOTAL	211170563.00	112574.53	258567560.00	133898.53	218479738.00	113330.56	403675.01	281194.67	707326.43	1652386.70	406311.71	2128700.28	601961.56	1173539.30



Technology Information, Forecasting And Assessment Council
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