Prospects of Ethanol & its Costing

BY

NARENDRA MOHAN
DIRECTOR
NATIONAL SUGAR INSTITUTE, KANPUR

Sugarcane – Source of Green Energy

JUICE → SUGAR

JUICE → Ethanol

BAGASSE ⇢ Ethanol

BAGASSE → CO-GENERATION OF ELECTRICITY

LEAVES & TOPS → BAGASSE

LEAVES & TOPS ⇢ CO-GENERATION OF ELECTRICITY

Ethanol….

The" Solar Energy In liquid Form".

When we want plant see to grow equal amount of biomass to renew what burnt for energy, the planted biomass consumes equal quantity of CO_2 which is released during burning, no more –no less.

IMPORTANCE OF ETHANOL

1.VALUE ADDITION: Production & sale of Ethanol is much more profitable than selling molasses as primary by product.

2. EBP SUCCESS: To cope up with the requirement of Ethanol @ approx. 2.68 billion liters for E-10 programme.

3. STABILIZED SUGAR PRODUCTION: To balance demand-supply position of sugar by diverting intermediate process liquors for ethanol production.

4. ENVIRONMENT PROTECTION: Clean and green form of renewable energy, avoiding use of fossil fuels.

5. FOREX ISSUES : To save foreign exchange required on import of crude oil.

……..& energy security

Revenue through sale of primary by-product (Standalone Sugar Units- conventional route)

(per ton of sugarcane)

Sl. No.	By-product	Quantity (ton)	Rate (per ton) (Rs.)	Revenue (Rs)
1.	Bagasse saved @ 7.0% on cane*	0.070	1600.00	112.00
2.	Molasses @ 4.5% on cane	0.045	5000.00	225.00
3.	Press Mud 3.5% on cane	0.035	250.00	8.75
			Total	**Rs.345.75 per ton of sugarcane i.e. Rs. 34.50 per qtl of sugarcane**

*Average bagasse % cane: 30 and considering installation of low to medium pressure boilers of 32 kg/ sq cm g to 45 kg/sq cm g working pressure having bagasse : steam generation ratio as 2.2 to 2.3 only. Power generation through back pressure turbines to meet sugar plant requirements only.

NATIONAL SUGAR INSTITUTE, KANPUR

Revenue through value addition (Integrated Sugar Complexes-considering High Pressure Co-generation & Ethanol production)
(per ton of sugarcane)

| Sl. No.	By-product	Quantity (ton)	Value added product	Rate (Rs)	Revenue (Rs)	Addl. Cost of conversion	Net Revenue (Rs.)
1.	Bagasse saved @ 9.0% on cane*	0.09	Power: 43.3 Units*	6.25 Per Unit	270.60	Rs. 2.00 per unit i.e. Rs. 86.60	Rs. 184.00
2.	Molasses @ 4.5% on cane	0.045	Ethanol: 10.6 liters#	42.00 Per liter	445.20	Rs. 10.00 per liter i.e. Rs. 106.00	Rs. 339.20
3.	Press Mud 3.5% on cane	0.035	Press Mud: 0.035 ton	25.00 Per qtl.	8.75	-------	Rs. 8.75
* Average bagasse % cane: 30 and considering installation of high pressure boilers of 87 kg/ sq cm g to 110 kg/sq cm g working pressure having bagasse : steam generation ratio as 2.5 to 2.6 only. Power generation through Condensing/Condensation-Extraction or in combination with back pressure turbines to meet sugar plant requirements and surplus for exports. # Considering an average yield of 235 liters of ethanol per ton of molasses. Note: The co-generation i.e. export of surplus power is being carried out by around 250 sugar factories, whereas, about 160 sugar factories have integrated distillation units for production of alcohol.					**Total**	**Rs.531.95 per ton of sugarcane i.e. Rs. 53.00 per qtl of cane**

SUGAR-ETHANOL BALANCE

We are producing sugar more than the domestic requirement.

Availability of Ethanol through conventional route is less than requirement for the desired 10% blending programme.

There is need to balance Sugar-Ethanol production to have stable sugar availability for domestic consumption and required quantity of Ethanol for EBP 10.

Such balance through Flexi Sugar Factories is desirable for sugar supply-demand balance and EBP success.

7

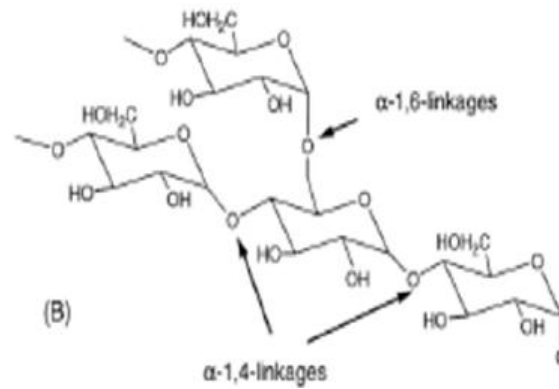# RAW MATERIALS FOR ALCOHOL PRODUCTION

Simple

→ Sucrose
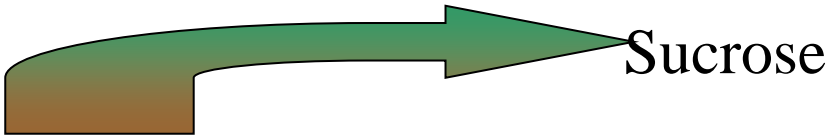
Single Stage Hydrolysis
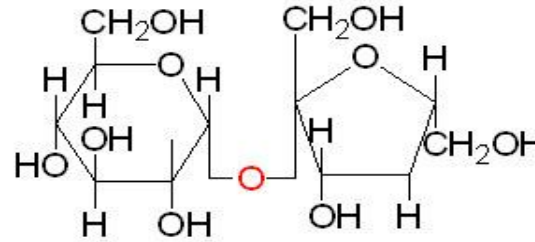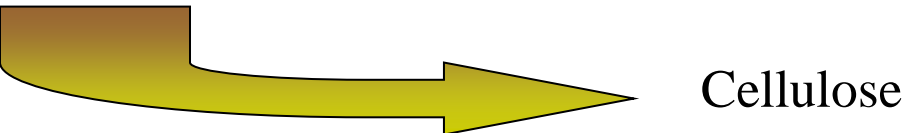
Cane juice ; Beet juice; Molasses

Moderate

→ Starch

Complex

Two Stage Hydrolysis

Cassava; wheat rice; sorghum; millets

α-1,6-linkages

α-1,4-linkages

(B)

Most Complex

→ Cellulose

Pretreatment Followed by Liquefaction

Plant Cell Wall

Cellulose

Lignin

Hemicellulose
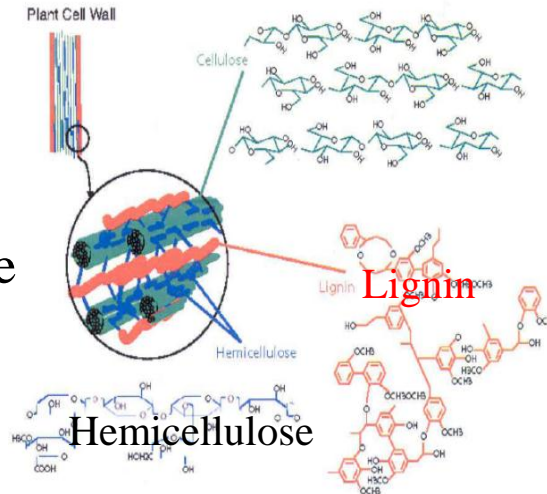
Bagasse; wheat & rice straw; grass

World Ethanol production by feedstock
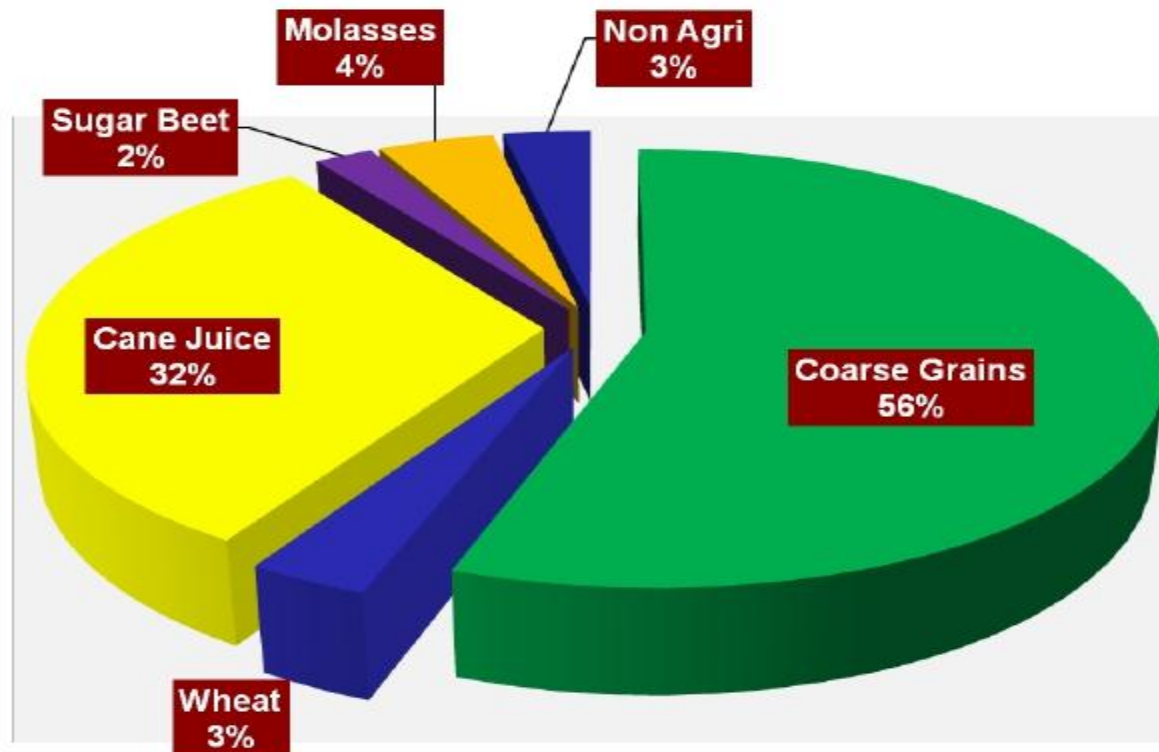
Total Ethanol= 105 billion ltrs

Installed base in India over 6 billion liter mark

Total Installed base= 6.25 Billion Ltrs per annum

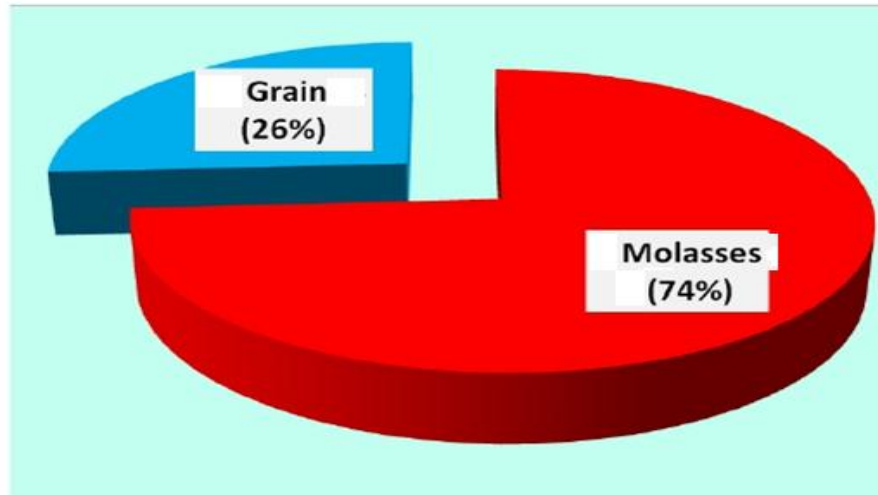- **Grain Plants - Major Locations**:

Maharashtra, Andhra Pradesh ,MP , Punjab, Haryana, Rajasthan

10

Installed Capacity Base….

1. Gross Distillation Capacity: +6.25 Billion Liters per annum, including grain.

2. About 74% installed capacity is molasses based and 26% grain based.

3. Ethanol Production Installed base: Approx. 2.25 Billion Liters per annum.(156Units)

in KLPA

S.No.	EtOH capacity (units attached with Private Sugar Mills)	EtOH capacity (units attached with Co-operative Sugar Mills)	EtOH capacity (Stand alone units)	Total
1.	1424850	576600	237300	2238750

OVERVIEW OF SUGAR & MOLASSES PRODUCTION

S.No.	Sugar Season	No. of Sugar factories in operation	Sugarcane produced (Lakh tonnes)	Sugarcane Crushed (Lakh tonnes)	Sugar Produced (Lakh tonnes)	Molasses Produced (Lakh tonnes)
1.	2010-11	507	3423.82	2398.07	243.94	109.70
2.	2011-12	529	3610.36	2569.75	263.42	118.24
3.	2012-13	526	3411.99	2505.98	251.40	117.44
4.	2013-14[#] #Provisional	509	3483.84	2360.20	245.54	108.50

Considering 5 % diversion of molasses for export, cattle feed, other uses and wastage/deterioration etc. and assuming an average realistic yield of alcohol @ 235 liters/ton of molasses (considering average Total Reducing Sugar Content as approx. 47.5), the total possible production of alcohol :

Sugar Season	Total Molasses Production (Lakh tonnes)	Molasses available for alcohol production (Lakh tonnes)	Estimated Alcohol Production Potential (Crore liters)
2011-12	118.24	112.33	263.98
2012-13	117.44	111.57	262.19
2013-14	108.50	103.08	242.24
2014-15#	124.82	118.60	278.70

Provisional

SECTOR-WISE REQUIREMENT/AVAILIBILITY OF ALCOHOL

In crore liters

S.No	Particulars	2011-12	2012-13	2013-14	2014-15 (Estimated)
1.	Requirement for potable liquor industry	153.2	157.0	220.0	230.0
2.	Requirement for chemical and other industrial uses	104.3	88.5	80.0	80.0
3.	Total requirement for potable liquor & Chemical Industry	257.5	245.5	300.0	310.0
4.	Less Grain alcohol usage for potable liquor	52.5	75.0	140.0	150.0
5.	Net requirement for potable liquor & Chemical Industry (molasses based alcohol)	205.0	170.5	160.0	160.0
6.	Net availability of alcohol for EBP	58.98	91.69	82.24	118.70
7.	Less 5% loss on de-hydration	2.95	4.58	4.11	5.94
8.	**Net availability of Ethanol for EBP**	**56.03 (0.56 Billion liters)**	**87.11 (0.87 Billion liters)**	**78.13 (0.78 Billion liters)**	**112.76 (1.13 Billion liters)**

....so we need

1. Ethanol capacity to be raised from 2.25 billion liters/annum to say 2.75 billion liters

2. Use of alternate sources for alcohol/ethanol production to cope up with EBP 10........to meet shortfall of about 1.5 billion liters/annum.

Other process liquors for alcohol production

Cyclic nature of the Indian Sugar Industry and various other factors effect the availability of molasses for ethanol production. Thus, there is need to look for other feed stocks to cope up with ethanol requirements for EBP10, and as far as sugar factories are concerned following may be the alternatives:

1. **Ligno-cellulosic Ethanol from bagasse.**
2. **Directly from sugarcane juice.**
3. **Diversion of Secondary juice.**
4. **Diversion of Filtrate (filtered juice).**
5. **Diversion of B-Heavy Molasses.**

DIVERSION OF B HEAVY MOLASSES FOR ETHANOL PRODUCTION

---Diversion shall help in keeping the production of sugar as per requirement & in coping up with the increased requirement of Ethanol to make EBP a success….

NATIONAL SUGAR INSTITUTE, KANPUR

Chemical Composition of B- Heavy and Final Molasses

S.No	PARAMETERS	B-HEAVY MOLASSES	FINAL MOLASSES
1	Reducing sugars (g %)	4-16(10)	10-16(13)
2	Total Reducing sugars (g %)	50-89(54)	40-50(45)
3	UFS (g %)	2.00-3.00(2.5)	4.00-6.00(5.0)
4	Volatile fatty acids (ppm)	2000-2500	3400-4000
5	pH	4.8-6.0	4.8-6.0

Fermentative Production of Alcohol from Intermediate Molasses

S.No	PARAMETERS	B-HEAVY MOLASSES	FINAL MOLASSES
1	Weight of molasses	1000g	1000g
2	Initial TRS content g/100 ml	14.86%	13.75%
3	UFS (g/100 ml)	0.60%	1.12%
4	FS (g/100 ml)	14.26%	12.63%
5	Theoretical ethanol yield (% v/v)	9.183%	8.13%
6	Practical ethanol yield (% v/v)	7.42%	6.73%
7	Ethanol yield (litre/ ton)	296.8	235.5

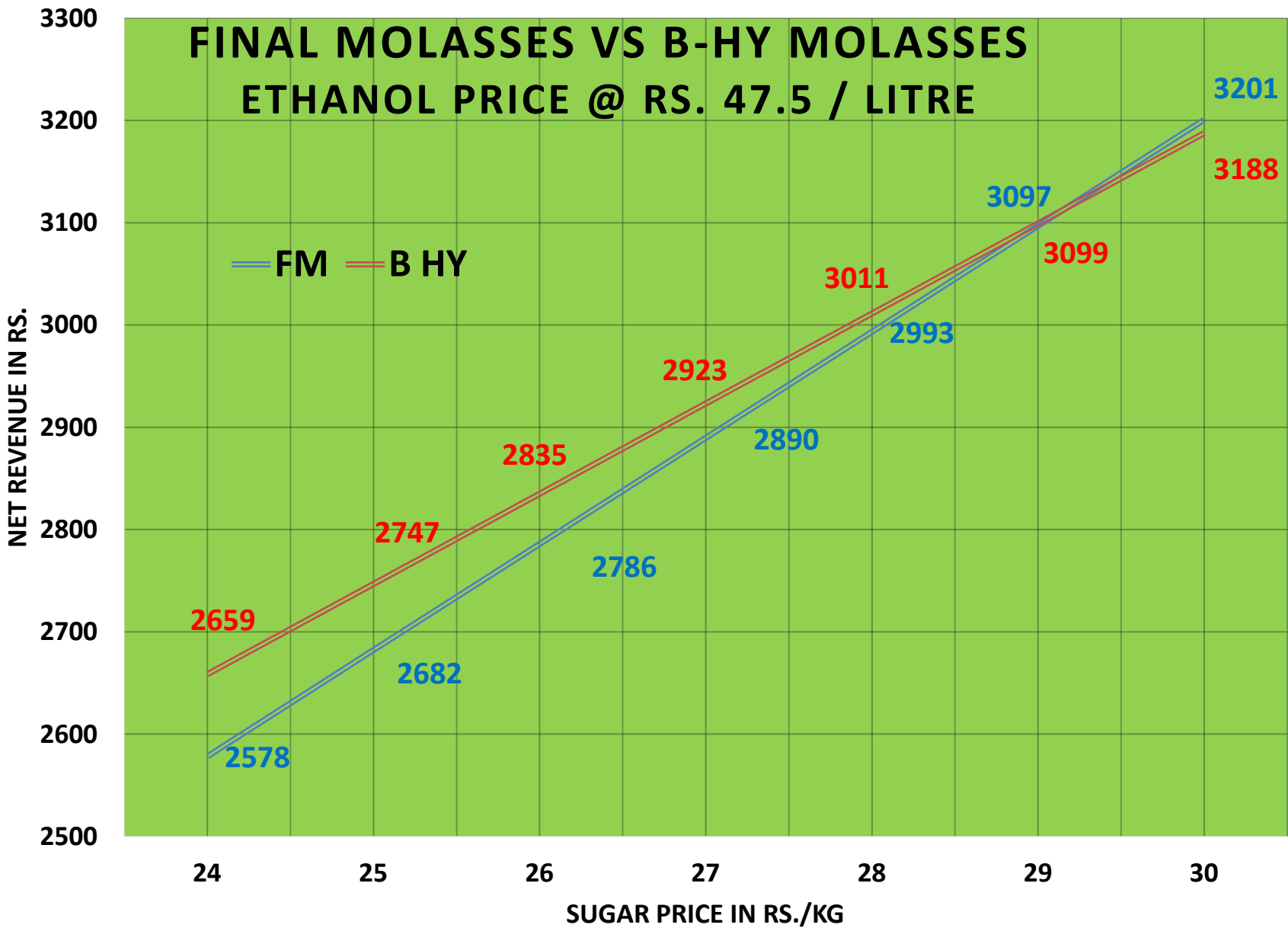# Comparison of data of B-heavy molasses and final molasses trial done at Dhampur Distillery

S.No.	Particulars	Units	FM	BH
1.	Molasses Consumption	Qtls	7500	7950
2	Total Production (95 %)	Litre	188201	224096
3	Ethanol Production	Litre	159000	198237
4	Spent Wash Generation	Litre/Litre	8.6	6.99
5	Fusel Oil	Litre	Nil	NIL
6	Steam Consumption kg/l	Tons	2.14	1.83
7				
8				
9	MEE(Feed Rate-960 M^3)(Exhaust)	Tons	202	U/Cleaning
10	ENA	Kg/Litre	1.8	1.8
11	Power Consumption kw/l	kwh	0.096	0.074
12	Fermentation Efficiency	%	88	89.7
13	Distillation Efficiency	%	97.6	97.6
14	Yield	Litre/Ton	225	281.8
15	Loss on Spent Wash		NIL	NIL
16	Loss in Spent Lees		NIL	NIL
17	Storage Deterioration	Unit/6 month	2.5	3.5
18	Molasses TRS	%	44.1	52.1
19	Unfermentable Sugar	%	6.28	Data NA
20	Volatile Acids	mg/litre	5143	4971

Sl. No.	Particulars	Units	Three Massecuite Boiling	Two Massecuite Boiling
1	Cane	Ton	1	1
2	Recovery	% Cane	10.37	8.81
3	Quantity of Sugar Produced	Kg	103.70	88.15
4	Sugar Price	Rs. / Kg	29	29
5	Gross Revenue from Sugar	Rs. / Ton Cane	3007	2556
6	Conversion Cost	Rs. / Kg	5.75	5.75
7	Net Revenue from Sugar	Rs. / Ton Cane	2411	2049
8	Molasses	% Cane	4.5	6.58
9	Quantity of Molasses Produced	Kg	45	65.8
10	Ethanol Production Rate	Litres per Ton of Molasses	223.25	294.50
11	Quantity of Ethanol Produced	Litres	10.05	19.38
12	Ethanol Price	Rs. / Litre	42	42
13	Gross Revenue from Ethanol	Rs. / Ton Cane	422	814
14	Conversion Cost	Rs. / Litre	10	9.5
15	Net Revenue from Ethanol	Rs. / Ton Cane	321	630
16	Power Export	KWh	71.78	73.93
17	Power Price	Rs. / KWh	6.25	6.25
18	Gross Revenue from Power	Rs. / Ton Cane	449	462
19	Conversion Cost	Rs. / KWh	2	2
20	Net Revenue from Power	Rs. / Ton Cane	305	314
21	Press Mud	% Cane	3.5	3.5
22	Quantity of Press Mud Produced	Kg	35	35
23	Press Mud Price	Rs. / Kg	0.26	0.26
24	Net Revenue from Press Mud	Rs. / Ton Cane	9	9
25	Total Net Revenue	Rs. / Ton Cane	3047	3003
26	**Difference**	**Rs. / Ton Cane**		**-44**

FINAL MOLASSES VS B-HY MOLASSES
ETHANOL PRICE @ RS. 42 / LITRE

NET REVENUE IN RS.

SUGAR PRICE IN RS./KG

FM   B HY

3150
3091
3047
3002
2943
2914
2839
2826
2736
2738
2650
2632
2562
2528
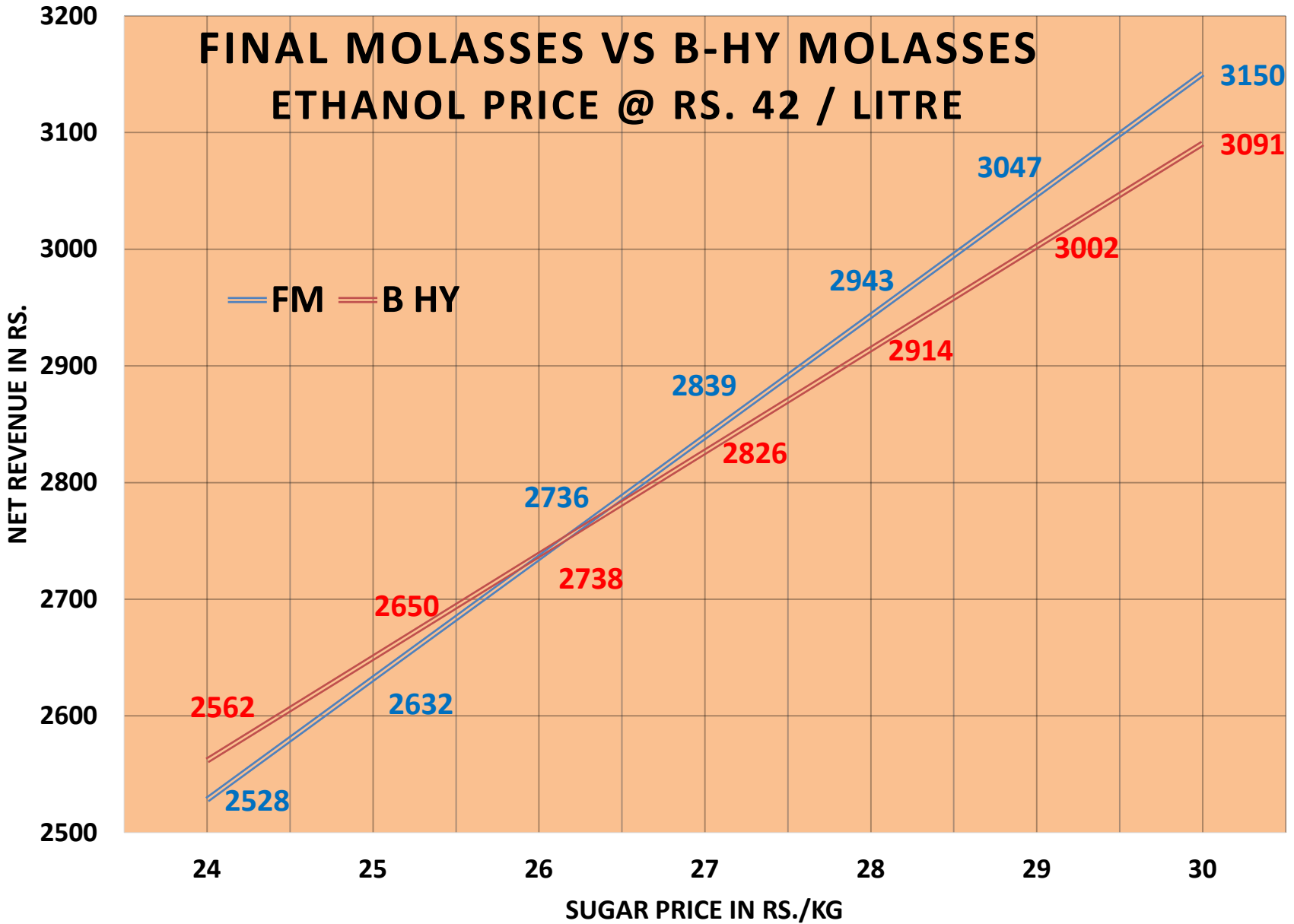
FINAL MOLASSES VS B-HY MOLASSES
ETHANOL PRICE @ RS. 47.5 / LITRE

NET REVENUE IN RS.

SUGAR PRICE IN RS./KG

FM   B HY

3201
3188
3097
3099
3011
2993
2923
2890
2835
2786
2747
2682
2659
2578

Integrated Production of Sugar and Ethanol

➢ Variation on the ratio of sugar and ethanol produced according to the market will result in sugar price stabilization and coping up with the requirement of EtOH for EBP.

➢ Sugar of better quality – no need to recycle molasses of low purity and thus price premium over the produce

➢ Higher purity in the mash (high purity molasses) for high fermentation yield

➢ Energetic optimization – Energy saving in sugar plant

➢ Reduced packing cost and expenditure on manpower

➢ However, the economics of B Heavy diversion shall be dependent upon the price of the Sugar vis a vis Ethanol.

24

Alternate Feed Stocks for Alcohol/Ethanol Production

Alcohol in India is mainly produced from cane molasses, the by product of cane sugar industry. However, due to cyclic nature of sugar cane, the sugar and molasses production has been quite variable as a result of which capacity utilization of distilleries remains much lower. Other feed stock which can substitute molasses for the fermentative production of ethanol include Sugar Beet, Sweet Sorghum and Cassava etc.

Feedstock for Ethanol Production

SUGAR BEET

Considering the advantage of sugar beet cultivation and problems in subtropics, the thermo insensitive varieties have been developed and the trials carried out in winters revealed that the yield ranges from 60-75 t/ha. The expressed juice of Sugar Beet can be utilized for the fermentative production of alcohol with a possible yield of 100 liters/ton of beet.
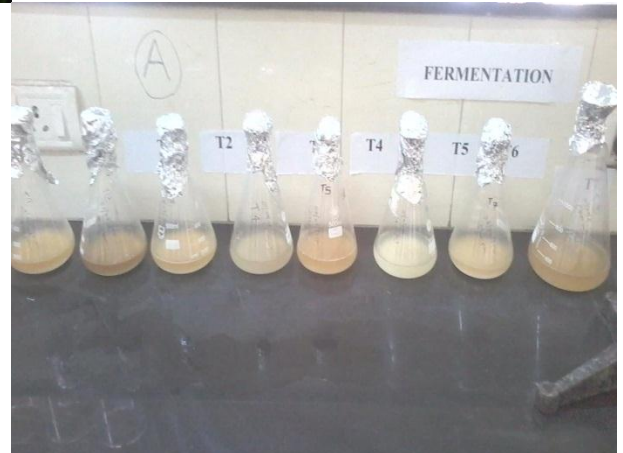
NATIONAL SUGAR INSTITUTE, KANPUR
Fermentative production of alcohol from Sugar Beet Juice

S.No	PARAMETERS	RESULT
1	Qty of sugar beet	3k g
2	Final volume of juice	5 L
3	TRS content	11.4%
4	Theoretical ethanol yield %v/v	7.34%
5	Practical ethanol yield % v/v	6.10%
6	Fermentation efficiency	83.1%
7	Ethanol yield	101.6 litre/ ton

SWEET SORGHUM

India is the second largest producer of sweet sorghum

Sweet sorghum has been noted for its potential as an energy crop. Sweet sorghum can be cultivated in nearly all temperature and tropical climatic areas.

The stalks contain fermentable sugars which can be fermented to produce alcohol. The fermentation studies conducted have shown that sweet sorghum can give a yield of 45 liters/ton of alcohol.

30

Fermentative production of alcohol from sweet sorghum

1.	Quantity of sweet sorghum stalk	2.5 kg
2.	Volume of juice	1.0 liter
3.	TRS content	17.9%
4.	Unfermentable sugars	Nil
5.	Theoretical ethanol yield (% v/v)	11.52
6.	Practical ethanol yield (% v/v)	11.17
7.	Fermentation efficiency	96.96
8.	Ethanol in 1 liter juice	111.7 ml
9.	Ethanol in 1000 liters juice	111.7 liters
10.	Ethanol yield (liter/ton of sweet sorghum stalk)	44.68

CASSAVA

CASSAVA

The most productive Cassava farms in the world were observed to be in India, with a nationwide average yield of 33 tonnes per hectare. Cassava is a potential crop for ethanol production because it produces high yield and boats tremendous starch content, therefore producing high ethanol production per ton. Compared to wheat, corn or sugar cane, cassava ethanol yields amount up to about 150 liters/ton. At present, Starch is the most important value added product produced from Cassava.

It is also intercropped with short duration crops like black gram, groundnut, coconut, rubber and vegetables in the states of Tamil Nadu and Karnataka. This provides additional income to small and marginal farmers.

Fermentative production of alcohol from Cassava Powder -

1	Qty of cassava flour	100 g
2	Starch content	74.6%
3	Starch Content (Dry wt basis)	65.6%
4	Final Volume	650 ml
5	Fermentable Sugars	56%
6	Fermentable Sugars conversion	85.4%
7	Total sugar (g/100ml)	8.61%
8	Ethanol yield theoretical	5.54 % v/v
9	Ethanol yield practical	4.9 % v/v
10	Fermentation efficiency	88.4 %
11	Ethanol yield	354 litre/ton

SO, ETHANOL MATTER US IN INDIA ....AND WE HAVE TO WORK ONE

 #   DISTILLERIES ATTACHED TO SUGAR FACTORIES AND PRODUCING ALCOHOL ONLY (21 NOS.),

 #   DEVELOPING FLEXI SUGAR FACTORIES AND BIO-REFINERIES.

 # ADOPTING ALTERNATE MEANS OF ETHANOL PRODUCTION VIZ. DIVERSION OF INTERMEDIATE PROCESS LIQUORS & USE OF OTHER FEED STOCKS.

 # PRODUCTIVITY IMPROVEMENT BY IMPROVEMENT IN PLANT EFFICIENCY

 #   BALANCING SUGAR & EtOH PRODUCTION AS PER DEMAND AND ECONOMICS.

Jai Hind…………