The changing landscape of co-products from the bio-fuels industry (distiller's grains and glycerol)

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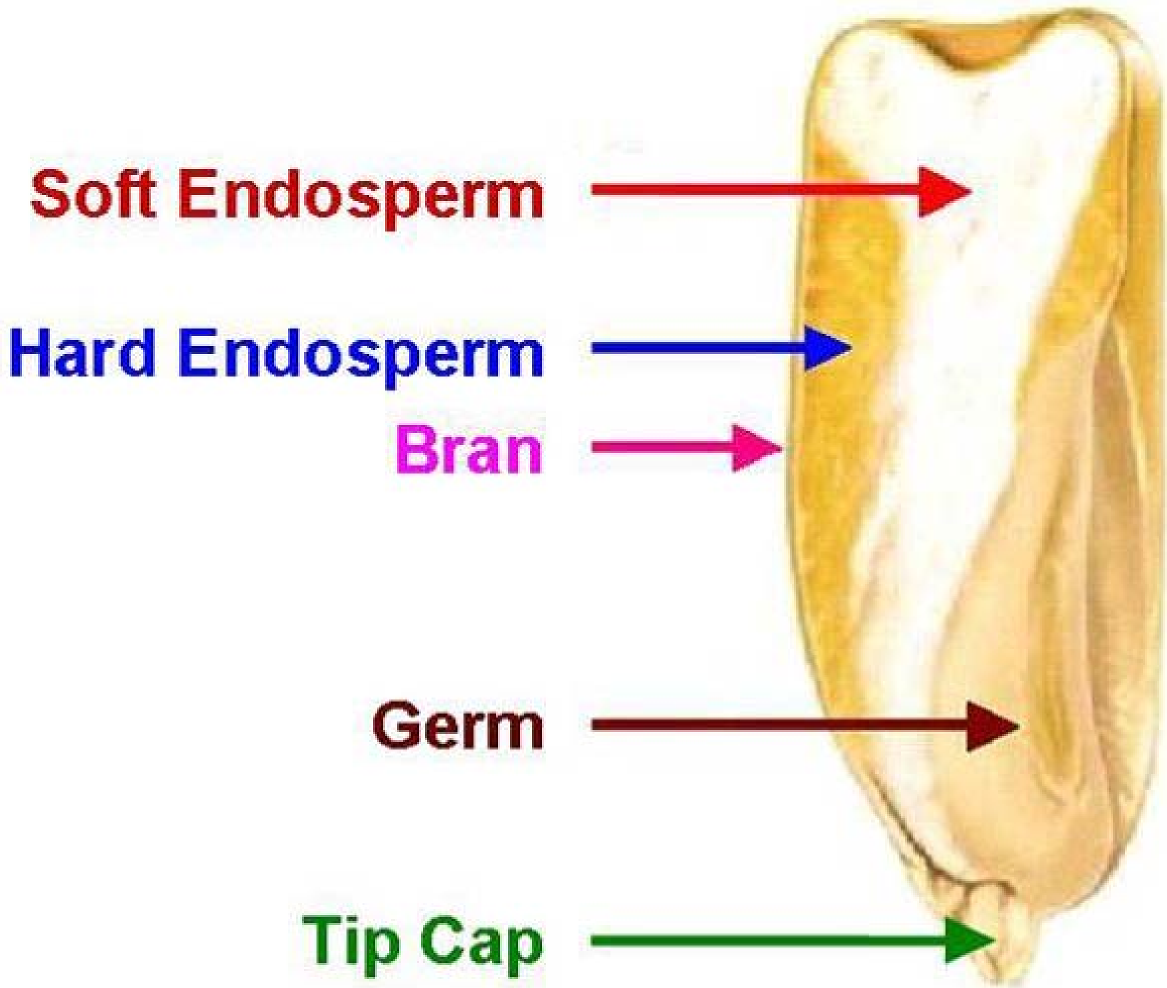
Why plants may change the DGS co-products produced?

- Plants need more income
  - Divide corn kernel into fractions (fractionation)
- Moderate payback- 5-6 years
  - Approximately 15M for 50M gal plant
- Increase revenue by $.15/gal
- Increase capacity by 13-18%
- Reduction in natural gas usage by 80%
- 20-25% less enzyme use
- .5 gallon less water/ gallon of ethanol
- Reduced emissions during drying

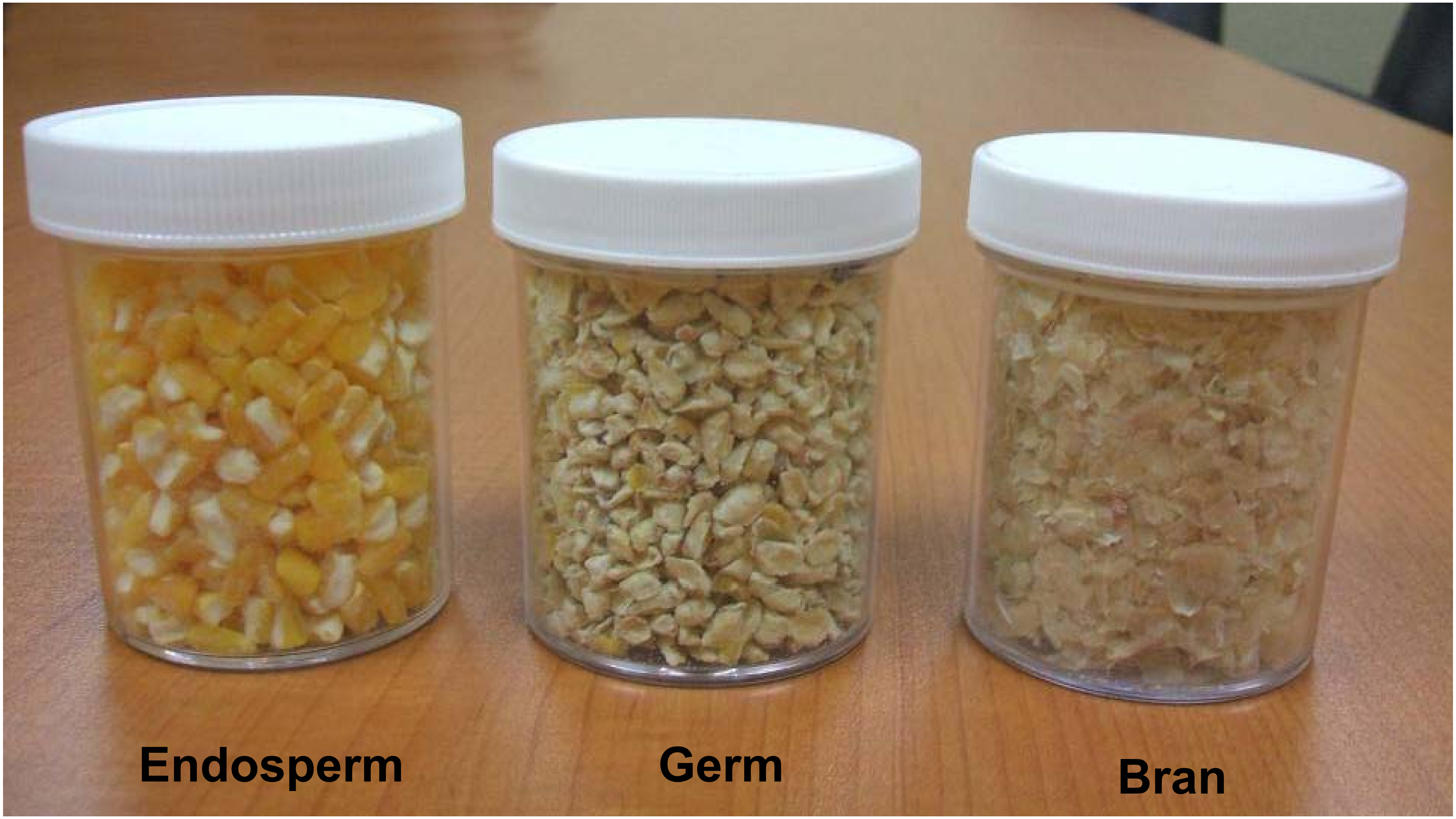
Why plants may change the DGS co-products produced?

- Only a portion of the plants will convert
  - A few plants per year
  - Not feasible for all plants
- Higher value co-products targeted for dairy, poultry and swine

Corn Fractionation



Corn Fractionation



Corn Fractionation Proportions

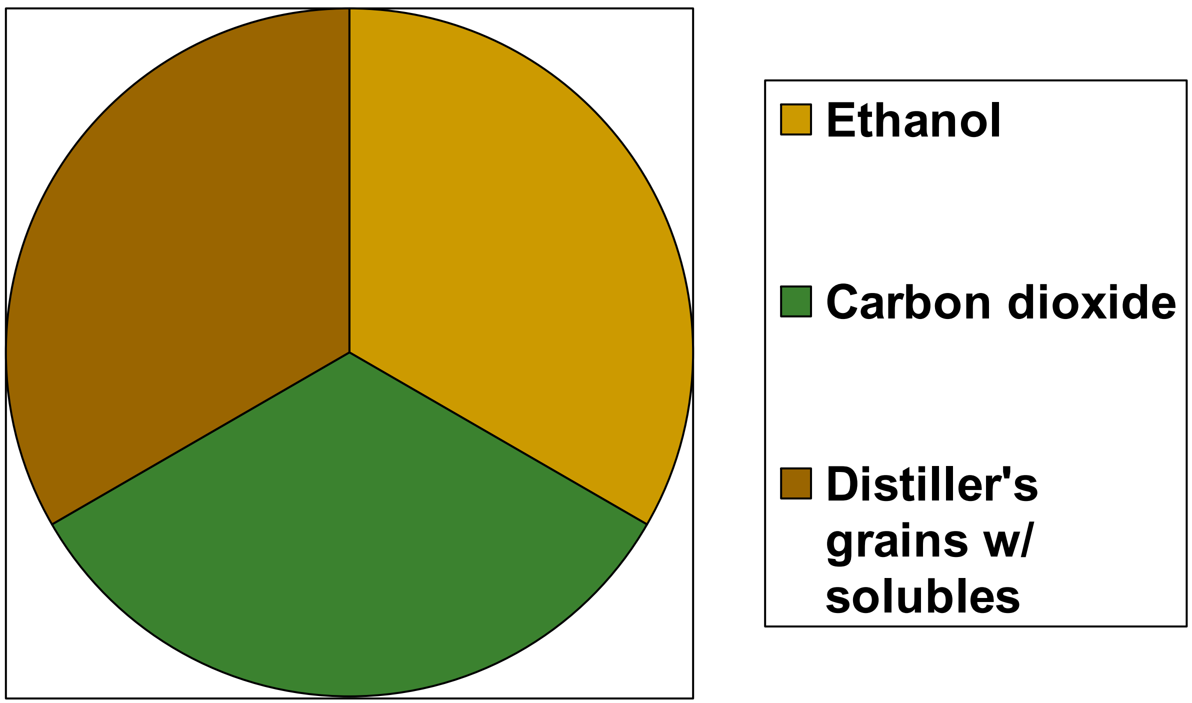
How plants may change the DGS co-products produced?

- Fractionate
  - Poet- BFrac™ Process
  - ICM- Dry Factionation
- Remove fat post-distillation
  - Fat is usable for bio-diesel or livestock feeds
  - $1.5 M for a 50 M gal plant

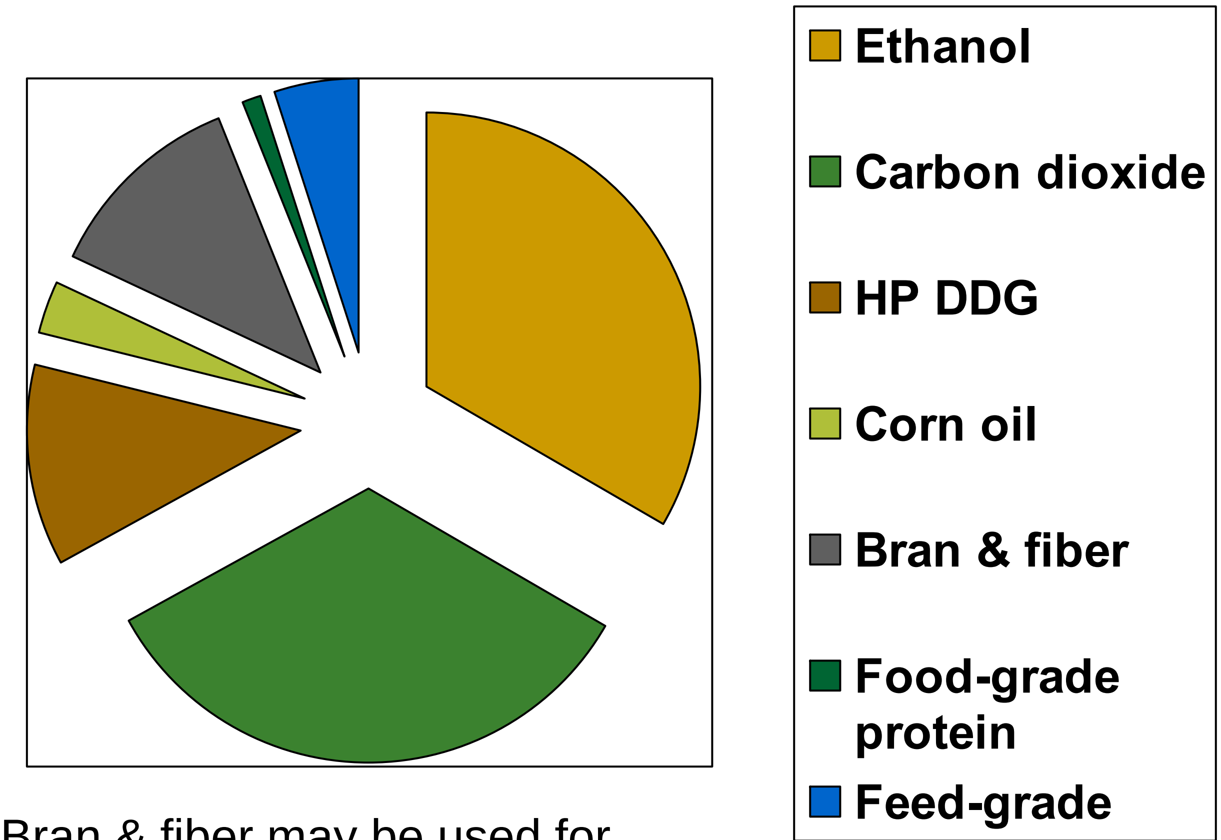
New co-products

- DDGS-BPX
  - New generation DDGS
  - Eliminates cooking prior to fermentation (uses selected enzymes)
  - Golden color
  - Patented process for Poet plants

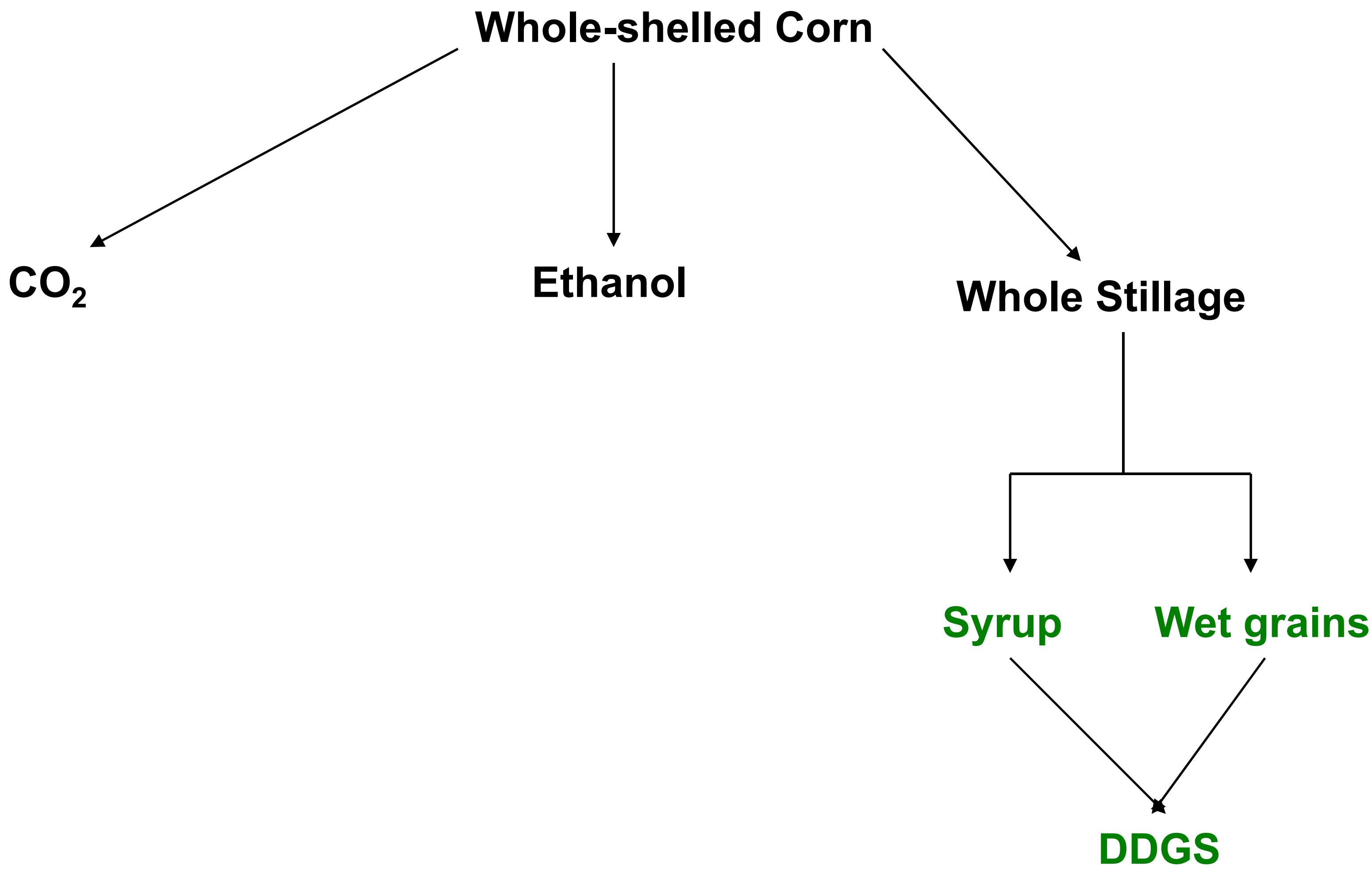
Current products produced in ethanol plants



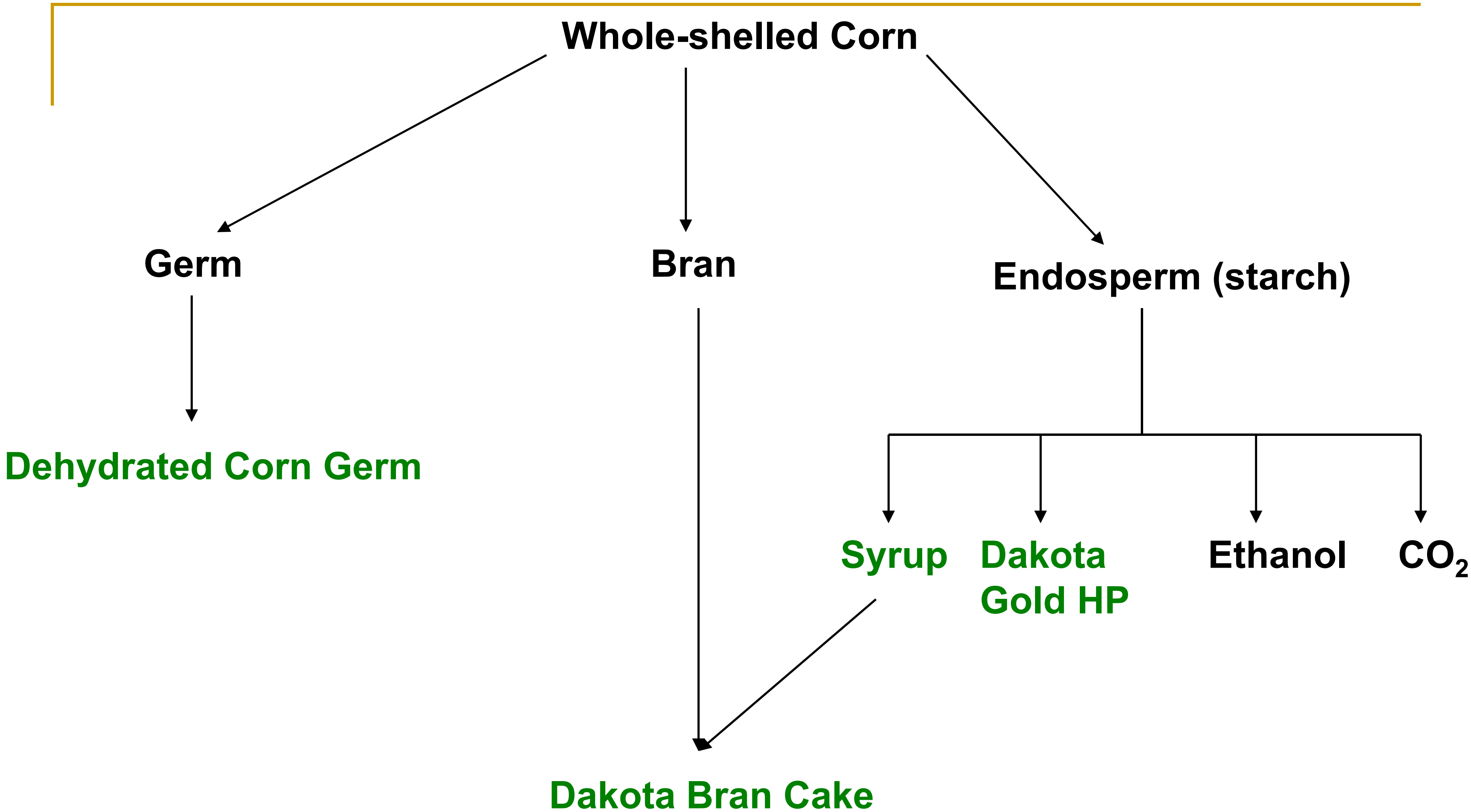
Future products that may be produced in ethanol plants



Bran & fiber may be used for cellulosic ethanol



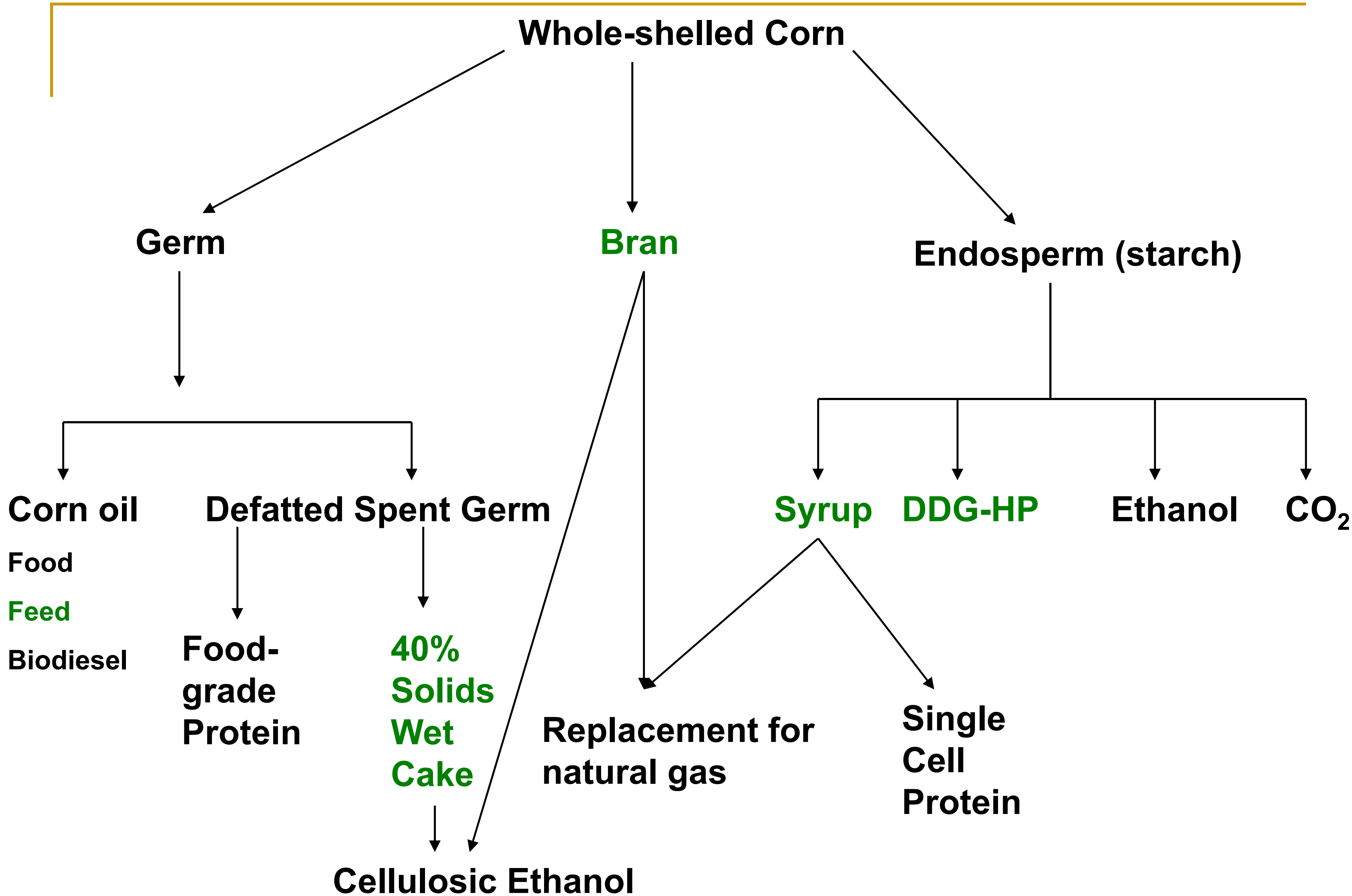
Current Fermentation Process



Poet BFrac Process

New co-products

- High protein distiller's grain (DDG-HP)
  - Equivalent to DDG-BPX except part of the germ and corn bran is removed prior to fermentation
  - DDGS resulting from BFRAC corn fractionation (Poet)
- Dehydrated dry milled corn germ
  - Separated prior to fermentation

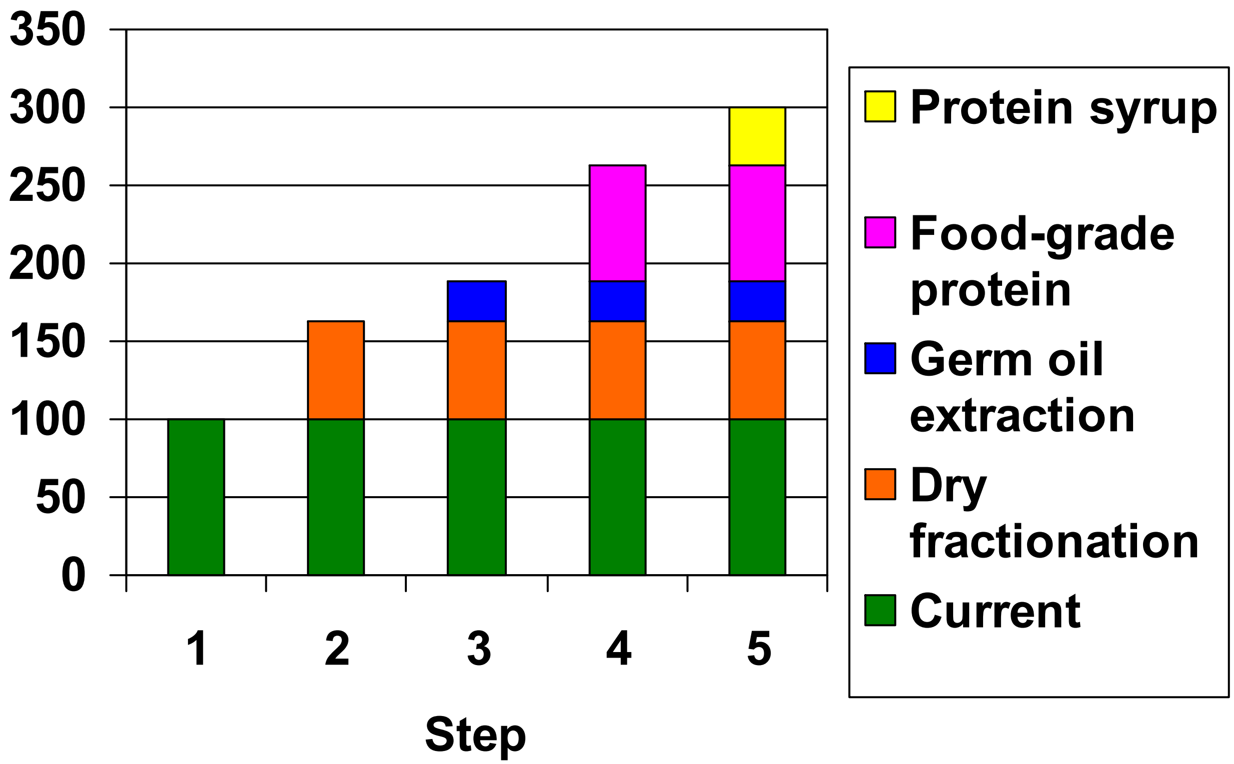


ICM Dry Fractionation Process

Summary of benefits of dry fractionation for an ethanol plant

- **Increased value of co-products**
  - **Feed- grade bran and single cell protein**
  - **Germ to food-grade protein and corn oil**
  - **High protein DG**
  - **Cellulosic ethanol from bran and germ fiber**

Progression of changes in co-products (ICM)



It will take a few years for changes to occur.

Nutrient analysis of new co-products from Poet plants

	DDGS	DDGS-BPX	SEM[a]	DDG-HP[b]	DCG[b]
# samples	10	10		10	10
DM, %	91.2	90.3	1.47	93.9 (.50)	94.7 (.51)
Ash, %	4.17	4.18	.15	1.90 (.06)	5.63 (.03)
C. prot., %	27.8	28.3	.76	41.1 (.75)	14.7(1.64)
Insol. Prot., %	10.4[d]	6.70[c]	1.04	5.8 (.63)	2.0 (.50)
Fat, %	11.30	10.70	.57	5.30 (.71)	19.00 (.48)
Starch, %	6.60	7.40	.72	11.40 (.72)	21.10 (1.36)
NDF_{om},%	33.6[d]	27.7[c]	1.5	23.0 (1.2)	29.0 (1.9)
ADF,%	12.1[d]	9.6[c]	.05	11.10 (.56)	8.90 (.8)
NE_L, MJ/lb	1.00	1.03	.03	1.04 (.01)	1.11 (.02)

[a]Standard error of the mean

[b]Values in parentheses are S.D. for adjacent mean

[cd]Means differ (P<.05)

Robinson et.al. (2008)

Nutrient analysis of new co-products from Poet Plants

	DDGS	DDGS-BPX	SEM[a]	DDG-HP[b]	DCG[b]
# samples	10	10		10	10
Ca, %	.04	.03	.006	.01 (.004)	.02 (.05)
P, %	.84	.80	.025	.45 (.01)	1.24 (.07)
K, %	1.12	1.16	.048	.39 (.01)	.48 (02)
S, %	.64[c]	1.05[d]	.071	.76 (.04)	2.0 (.50)
Na, %	.18[c]	.25[d]	.05	.13 (.004)	.01(.03)
Zn, ppm	254[f]	103[e]	23.8	68 (5.8)	91(2.8)
Cu, ppm	4.9[c]	6.6[d]	.71	4.4 (.27)	9.3 (.77)
Mo, ppm	.7[e]	1.1[f]	<.01	.9 (.03)	1.1 (.07)
Se, ppm	.28[e]	.94[f]	<.001	.89 (.07)	.51 (.05)

[a]Standard error of the mean

[b]Values in parentheses are S.D. for adjacent mean

[cd]Means differ (P<.05)

[ef]Means differ (P<.10)

Robinson et.al. (2008)

Nutrient analyses of new corn co-products

	DDG-HP[1]	Dehy. Corn germ[2]	Bran[3]	Deoiled DDGS[4]
DM, %	91.7	91.1	89.0	90.0
C. prot., %	43.2	16.3	14.6	34.9
NDF,%	24.2	23.2	30.4	38.2
ADF,%	12.2	8.2	…	12.9
Fat,%	3.9	17.3	9.8	3.0
Ash,%	2.4	6.0	4.6	4.6
Ca,%	.02	.02	.03	.04
P,%	.48	1.49	.65	.81
K,%	.47	1.62	1.12	1.06
Mg,%	.13	.60	.29	.38
S,%	.88	.21	.75	.80

[1]Dakota Gold HP

[2]Dakota Germ

[3]Dakota Bran

[4]Fat partially removed after fermentation (VeraSun Energy)

Kalscheur and Garcia (2008)

De-germed DDGS for heifers

	Control	13% DDGS	13% De-germed DDGS[a]	Prob.
# pens	8	8	8	---
Init. Wt., lb	765	765	765	1.00
Final wt., lb	1066	1073	1054	.42
ADG, lb	2.55	2.61	2.44	.16
DMI, lb/d	20.1[cd]	20.7[d]	19.7[c]	.04
Feed/gain	7.89	7.93	8.08	.57
Liver Abscess, %	4.9	4.9	3.9	.87

Depenbusch et.al. 2006

[a]De-germed DDGS- partially de-germed DDGS with 4% fat

[b]Final weight calculated by dividing hot carcass weight by .635

[cd]Means differ (P<.05)

De-germed DDGS for heifers

	Control	13% DDGS	13% De-germed DDGS[a]	Prob.
# pens	8	8	8	---
Hot Carc. Wt., lb	677	681	669	.42
Dress %	60.9	60.7	60.3	.17
KHP, %	2.24	2.24	2.20	.91
Backfat, in.	.32	.35	.32	.27
Marbling	385	392	397	.27
Yield grade	1.78	1.88	1.80	.46

[a]De-germed DDGS- partially de-germed DDGS with 4% fat

[b]Final weight calculated by dividing hot carcass weight by .635

Depenbusch et.al. 2006

Feeding distiller's syrup in feedlot diets

	0%[a]	4%	8%	12%	SEM[b]
# pens	4	4	4	4	---
Initial wt., lb	849	850	861	858	4.0
Final wt., lb	1269	1278	1283	1289	14.8
ADG, lb	3.86	3.92	3.87	3.95	.12
DMI, lb	20.0	21.1	21.3	20.8	.31
Feed/gain	5.21	5.40	5.51	5.27	.11
Hot carc. wt., lb	770	767	780	774	7.6
Dressing %	60.6	60.1	60.8	60.1	.37
Marbling	585	546	587	563	22.9
Choice ,%	81.8	87.0	86.4	83.3	
YG	2.28	2.20	2.32	2.29	.12

[a]Level of distiller's syrup (DMB); [b]Standard error of the mean

Trenkle and Pingel, 2004

[c]109 DOF; [d]No significant differences

Feeding Dakota Bran to cattle

	Control	30% DBran[a]	30% DDGS	$Prob._{branvsDDGS}$
Initial wt., lb	837	838	836	.71
Final wt., lb	1273	1315	1301	.87
DMI, lb/d	25.1	27.1	26.3	.19
ADG, lb	3.76	4.10	4.01	.90
Feed/gain	6.74	6.68	6.62	.33
Hot car. wt., lb	809	835	827	.84
Marbling[b]	567	561	544	.69
REA, in^2	13.7	13.7	13.6	.27
Backfat, in.	.39	.44	.44	.34
Calc.YG	2.55	2.77	2.77	.45

[a]Dakota Bran

Bremer et.al., 2006

[b]400=Slight;500=small

Feeding Dakota Bran to cattle

	Control	15% DBran	30% DBran[a]	45% DBran	Prob.
Initial wt., lb	837	836	838	836	
Final wt., lb	1273	1302	1315	1331	$L_{.01}$
DMI, lb/d	25.1	26.8	27.1	26.9	$L_{.01}$,$Q_{.01}$
ADG, lb	3.76	4.02	4.10	4.27	$L_{.01}$
Feed/gain	6.74	6.72	6.68	6.37	$L_{.01}$,$Q_{.08}$
Hot car. wt., lb	809	828	835	846	$L_{.01}$
Marbling[b]	567	567	561	550	
REA, in^2	13.7	13.7	13.7	13.9	
Backfat, in.	.39	.42	.44	.40	$Q_{.06}$
Calc.YG	2.55	2.68	2.77	2.63	

[a]Dakota Bran

Bremer et.al., 2006

[b]400=Slight;500=small

Effects of various ratios of syrup added to distiller's grains on cattle performance

	100:0[b]	85:15[b]	70:30[b]	Prob.
Initial wt., lb	856	857	857	NS
Final wt., lb	1399	1394	1412	NS
ADG, lb	3.88	3.84	3.96	NS
DMI, lb/d	25.4	25.1	25.5	NS
Feed/gain	6.54	6.49	6.41	NS
Hot car. wt., lb	882	878	889	NS
Backfat, in.	.60	.57	.60	$Q_{.10}$
Marbling[a]	545	541	560	NS
REA, in.^{2}	13.8	14.1	13.9	NS
Calc. YG	3.41	3.25	3.46	$Q_{.03}$

[a]Marbling score-400=slight;500=small

[b]Ratio of wet distillers grain to syrup

Godsey et.al., 2009

Summary of new products from ethanol industry

- Some plants will continue to sell WDGS and/or DDGS
- Some plants will further fractionate the corn kernel to get greater value co-products
  - Will occur over several years
  - May market some DDGS or WDGS (i.e. hiccups)
- Removing some of the fat does not limit the feeding value of DGS


Glycerin

Reaction to make biodiesel

CH_2OCOOR		CH2OH		RCOOR
CH_2OCOOR	+ 3 ROH ------>	CH2OH	+	RCOOR
CH_2OCOOR		CH2OH		RCOOR

100 of fat	10 lb methanol	10 lb glycerin	100 lb of diesel

Nutrient analysis of crude glycerin

	Elam et.al., 2008	Mach et.al., 2008
DM, %	86.1	91.4
Crude protein, %	1.4	-----
Glycerol, %	94.5	94.1
Total fatty acids, %	.27	-----
Ca, %	.10	-----
P, %	.07	-----
K, %	.24	-----
Na, %	3.32	-----
Salt, %	-----	5.5

Feeding glycerin to beef heifers

	0%[a]	7.5%	15%	Prob.
Initial wt., lb	828	825	825	.23
Final wt., lb	1261	1245	1238	.37
ADG, lb	3.61	3.49	3.43	.31
DMI, lb	20.8	20.4	19.7	.21 $L_{.09}$
Feed/gain	5.77	5.84	5.75	.43
Hot carc. wt., lb	771	768	763	.77
Dressing %	61	62	62	.46
REA, $in.^2$	14.7	14.7	14.6	.85
KHP, %	2.1	2.1	2.1	.82
Calc. YG	2.8	2.8	2.6	.39
≥Choice, %	86.2	78.5	66.5	.28 $L_{.15}$

[a]Level of added glycerin (DMB)

Elam et.al., 2008

[b]196 beef heifers; 4 pens/trt; 91% concentrate diet

Feeding glycerin to beef heifers

	0%[a]	2%	4%	8%	12%	16%	Prob.
Initial wt., lb	928	928	927	928	928	928	NS
Final wt., lb[b]	1151	1179	1168	1162	1146	1119	$L_{.01}$ $Q_{.01}$
ADG, lb	2.62	2.95	2.84	2.75	2.57	2.27	$L_{.01}$ $Q_{.01}$
DMI, lb/d	19.4	19.5	19.1	18.9	18.5	17.2	$L_{.01}$ $Q_{.01}$
Feed/gain	7.35	6.58	6.67	6.85	7.14	7.58	$Q_{.05}$
Hot carc. wt., lb	731	748	741	738	728	711	$L_{.01}$ $Q_{.01}$
Dressing %	62.0	64.1	64.2	63.3	63.4	63.6	NS
REA, in.^{2}	12.9	13.4	13.0	12.8	12.7	12.6	$L_{.01}$
KHP, %	2.24	2.21	2.19	2.24	2.20	2.19	NS
Backfat, in.	.48	.43	.46	.46	.46	.40	$Q_{.01}$
Calc. YG	2.5	2.4	2.5	2.6	2.5	2.3	$Q_{.05}$
≥Choice, %	57	50	59	43	52	39	$L_{.08}$

[a]Level of added crude glycerin (DMB)

Parsons et.al., 2008

[b]Calculated by division of hot carcass weight by .635

[c]373 beef heifers; 9 pens/trt; 94% concentrate diet; 85 DOF

Feeding glycerin to beef yearlings

	0%[a]	10%	Prob.
Initial wt., lb[c]	1021	1023	.20
Final wt., lb[c]	1377	1369	.16
ADG, lb	3.49	3.39	.19
DMI, lb/d	23.8	23.4	.31
Feed/gain	6.84	6.95	.43
Hot carc. wt., lb	857	852	.67
Dressing %	62.1	62.2	.91
≥Choice, %	74.1	75.9	.28 $L_{.15}$

[a]Level of added glycerin (DMB)

Elam et.al., 2008

[b]288 buckskin yearlings; 4 pens/trt; 93% concentrate diet

[c]Calculated with a 5% shrink

Glycerin summary

- Can feed up to 8% of the diet
  - Similar energy value as corn
- May result in smaller but more meals per day
- Limited affects on carcass characteristics

Feeding glycerin to beef bulls

	0%[a]	4%	8%	12%	Prob.
# of bulls	12	12	12	12	---
Initial wt., lb	739	737	735	733	.99
Final wt., lb[b]	1003	1030	1019	1000	.67
ADG, lb	2.88	3.15	3.08	2.84	.71
DMI, lb/d	18.0	18.0	18.8	18.0	.83
Feed/gain	6.25	5.88	5.88	6.25	.21
Hot carc. wt., lb	529	542	540	538	.46
Dressing %	52.3	53.1	52.9	52.5	.66
REA, in.^{2}	5.92	6.23	6.28	6.23	.86
Shear force, lb	9.2	8.8	8.4	8.3	.87

[a]Level of added glycerin (DMB)

Bach et.al., 2008