
The Potential of
COTTON SEED MEAL
as Livestock Feed

- Cotton is the fourth largest oil crop in the world, after soybean, rapeseed and oil palm.

- India ranked second in cottonseed production after China, only with a marginal difference.

-FAO, 2014

Production status in India (2016-17)

Area in lakh hectares	Productin in lakh bales or 170 kgs	Yield kgs per hectare	Availability of Cotton seed cake or meal (thousand tonnes)*
105.00	351.00	568.00	875.74

Source: Cotton Advisory Board (CAB)

* (Approximate) Calculated by using the equation as per Ramachandra et al., (2007)

State wise area, production and productivity of cotton (2016-17)

Ranking	State	Area (Lakh hectares)	Production (lakh bales of 170 kg)*	Yield (kgs per hectare)
1	Maharashtra	38.06	89.00	398
2	Gujarat	24.00	95.00	673
3	Telangana	17.78	59.50	569
4	Madhya Pradesh	5.99	21	596
5	Haryana	4.98	20.00	683
6	Karnataka	4.64	21.00	769
7	Andhra Pradesh	4.49	19.00	719
8	Rajasthan	4.42	18.00	692
9	Punjab	2.56	9.00	598
10	Tamilnadu	1.50	6.00	680
11	Orissa	1.36	3.00	375
	Others	0.50	2.00	680
	Grand Total	105.00	351.00	568

Source: Cotton Advisory Board (CAB)

*Inclusive of State-wise loose cotton production

Availability of Cotton seed for Processing in India

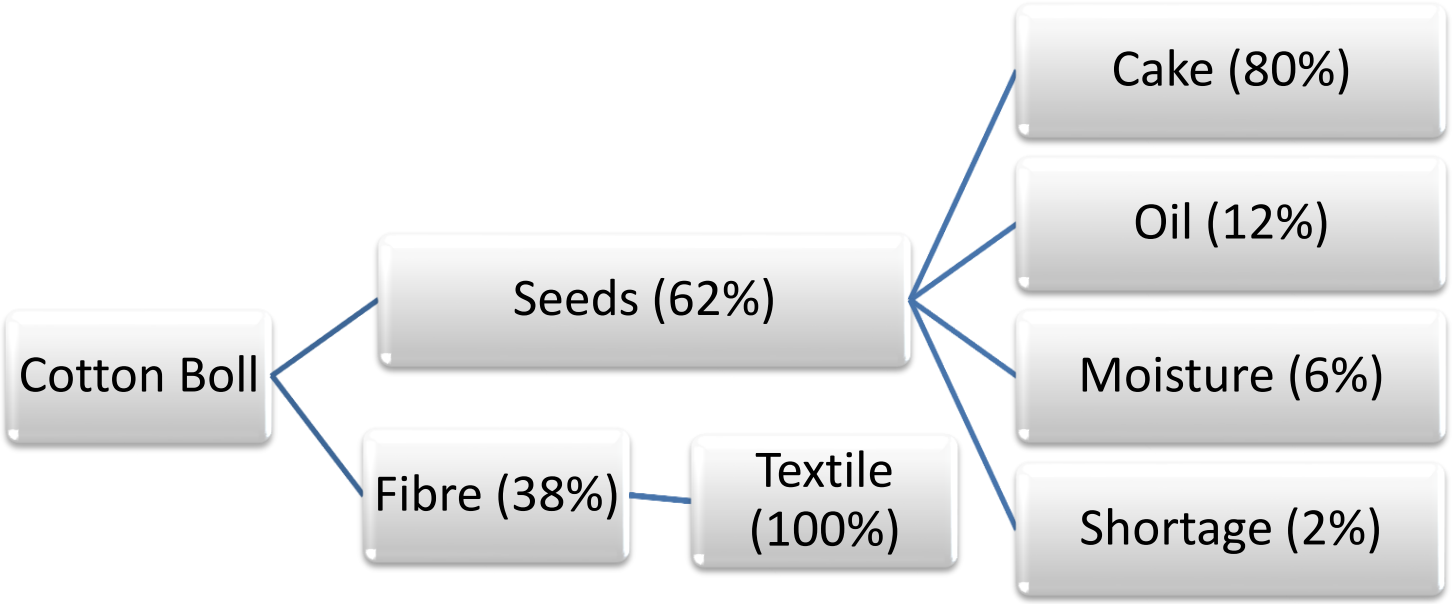
(In tonnes except cotton)

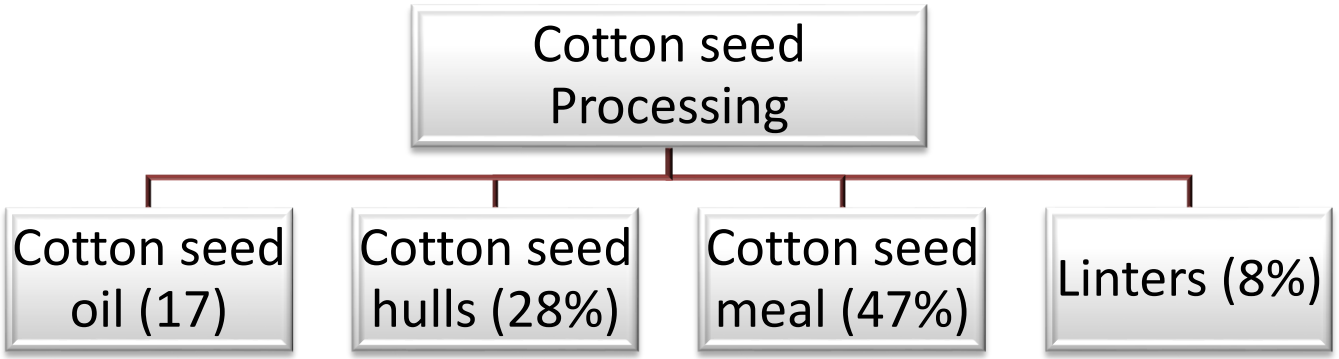
	2013-14	2014-15	2015-16	2016-17 (P)
Cotton production (Lakh bales)	398.00	386.00	338.00	351.00
Cotton seed production (@333 kg/bales)	132.53	128.54	112.5	116.88
Retained for sowing & direct consumption	5.00	5.00	5.00	5.00
Marketable surplus available	127.53	123.54	107.55	111.88

P = Projection

- Cotton statistics and news, 2017 (Issue 44, a News letter by cotton Association of India, 1921)

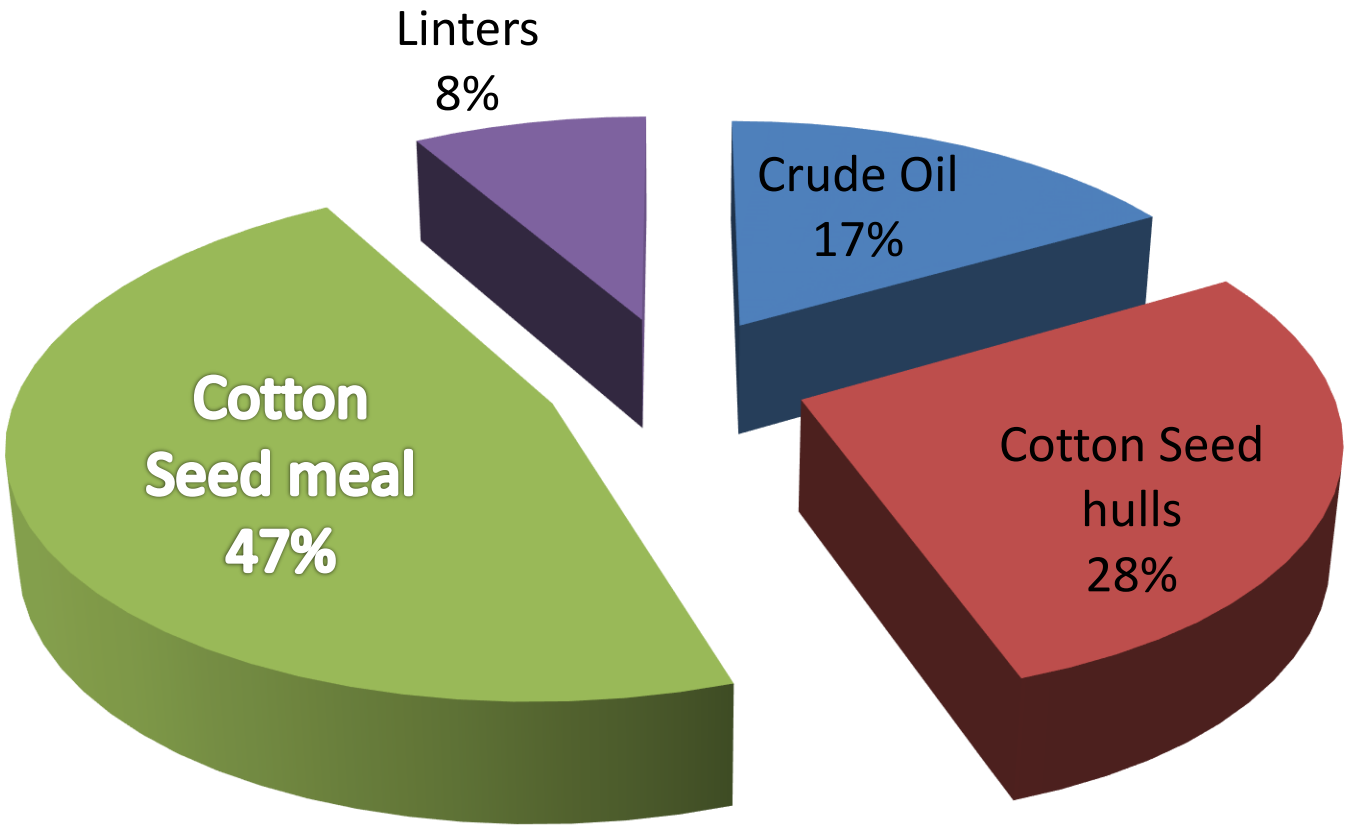
CSM is the by-product of oil extraction from cotton seeds





- O'Brien et al., 2005

Cotton Seed Processing



National Cottonseed Products Association, 2000

Various methods used for cotton seed oil extraction

Mechanical extraction

- Traditional method of cottonseed oil extraction.
- Uses a circular mortar (*Ghani*) or Hydraulic press or a screw press (expeller).
- Up to 20% of the seed oil may remain in the pressed cake, depending on the technology used.

- O'Brien et al., 2005

- About 95% of the cottonseed processed in the country is through the traditional method.

-Cotton statistics and news, 2017 (Issue 44, a News letter by cotton Association of India, 1921)

Ghani expeller (traditional cold pressed oil extracting unit) at Kothavalasa, Visakhapatnam, Andhra Pradesh

Direct solvent extraction

- Commonly used method of cottonseed oil extraction during 1980's.

- Oil is extracted by solvent (usually hexane) alone.

- The extracted cake is heated to eliminate the solvent and then generally ground into meal.

- Ash, 1992

200 tonnes per day capacity CSM solvent extraction plant at Mallepalli, Telangana State

Pre-press solvent extraction

- Combination of both mechanical and Solvent extraction steps.

- The dehulled, cracked, dried, heated or flaked cotton seeds are first screw-pressed or expanded and the pressed flakes or pellets are then solvent-extracted.

- Van Hoed et al., 2010

Pre-press solvent extraction unit

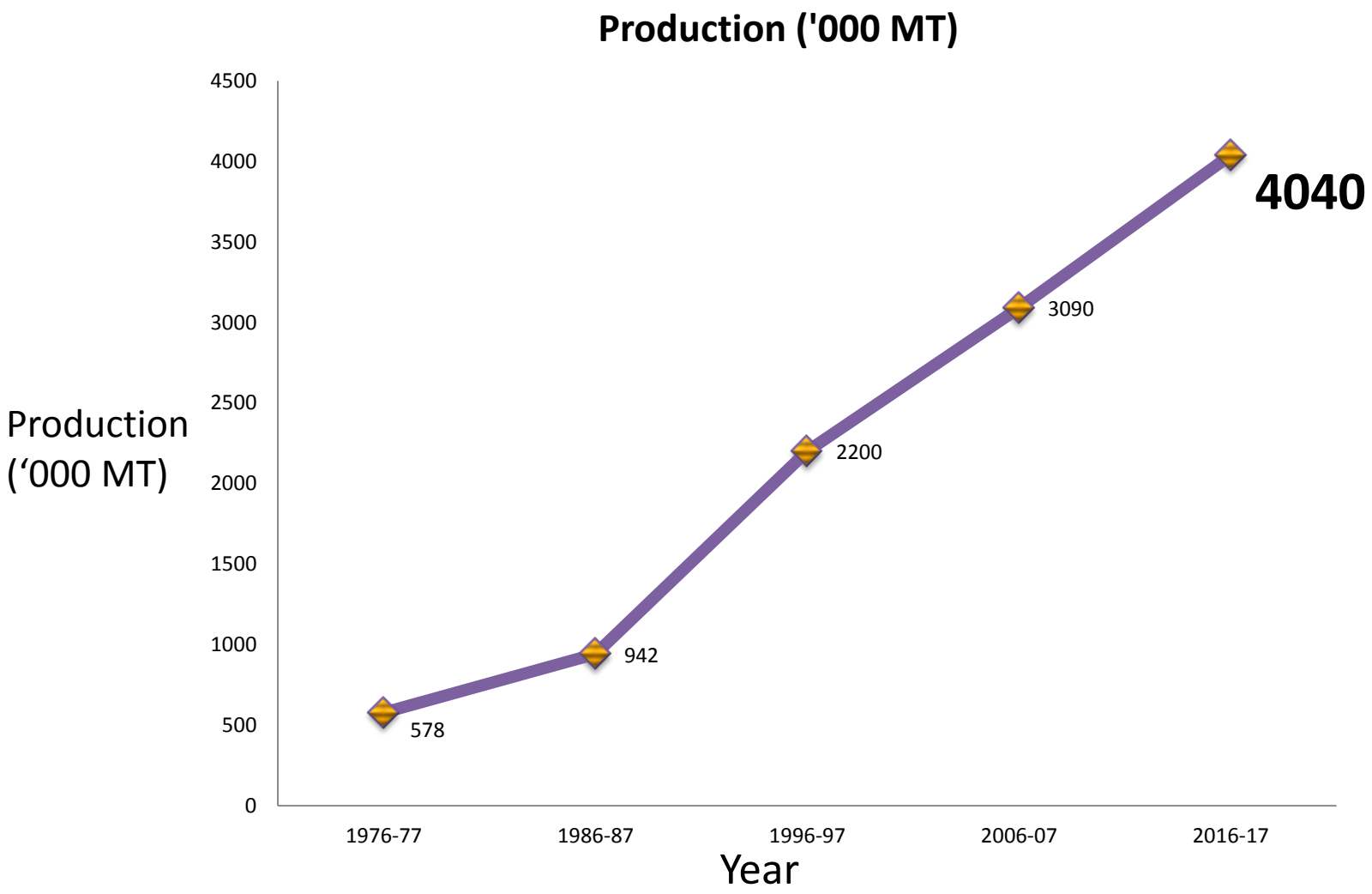
CSM is the product obtained by finely grinding the flakes which remain after removal of most of the oil from cottonseed by a solvent extraction process. It must contain not less than 36% crude protein.

- Association of American Feed Control Officials (AAFCO)

Cottonseed meal is the by-product of oil extraction from cotton seeds. As a protein-rich feed, cottonseed meal is a common source of protein for ruminants, notably in cotton-producing areas such as India, China and the USA, where it is used as a partial substitute for soybean meal.

- Heunze et al., 2016

Production status of cotton seed meal in India



-United States Department of Agriculture

https://www.indexmundi.com/agriculture/?country=in&commodity=cottonseed-meal&graph=production

MAJOR TRADING CENTRES OF COTTON SEED MEAL IN INDIA

GUJARAT
Kadi, Rajkot

PUNJAB
Abohar, Malout, Malhar

MAHARASHTRA
Amravati, Jalna, Akola, Beed, Parbhani

TELANGANA
Adilabad

ANDHRA PRADESH
Guntur

Source: Cotton Advisory Board (CAB)

ADVANTAGES OF CSM OVER OTHER PROTEIN SUPPLEMENTS

- Good nutrient composition
- Cheaper source
- High level of rumen-undegradable protein
- High acceptance level by farmers
- Year round availability
- Ever availability at commercial level

Proximate principles & Gossypol of CSM in comparison with SBM

Proximate principle / ANF	Soy-bean meal	Cotton Seed Meal							
	NRC (1994)	NRC (1994)	NCPA (2002)	Watkins et al., (2002)	Tang et al., (2012)	Salas et al., (2013)	Sun et al., (2013)	Zotte et al., (2013)	Thirumalai samy et al., (2015)
DM (%)	89.00	90.00	89.10	91.36	88.23	-	87.20	87.20	89.86
CP (%)	44.00	41.40	47.60	44.96	46.52	50.67	46.20	46.20	40.92
CF(%)	7.00	13.60	11.20	10.03	10.21	12.88	-	-	11.92
EE(%)	0.80	0.5	2.20	1.46	1.08	1.94	1.09	1.09	3.07
TA(%)	-	-	7.50	6.53	6.02	9.46	-	-	7.15
Total Gossypol	-	-	1.16	-	-	1.52	-	-	2.62
Free Gossypol	-	-	0.140	0.130	0.820	0.160	-	-	0.40
NDF(%)	-	-	17.30	-	-	-	-	-	-
ADF (%)	-	-	24.50	-	-	-	-	-	-

NCPA - National Cottonseed Products Association, 2002

Mineral profile of CSM in comparison with SBM

Mineral	Soy-bean meal	Cotton Seed Meal							
	NRC (1994)	NRC (1994)	NCPA (2002)	Sahin et al., (2006)	Tang et al., (2012)	Salas et al., (2013)	Sun et al., (2013)	Zotte et al., (2013)	Thirumala isamy et al., (2015)
Ca (%)	0.36	0.15	0.22	0.24	0.25	0.24	0.25	0.24	0.22
Total P (%)	0.66	0.95	1.20	1.10	1.11	1.71	1.21	0.79	1.16
Cu (mg/kg)	22.00	18.00	12.50	-	-	-	-	-	-
Iron (mg/kg)	120.00	110.00	126.00	-	-	-	-	-	-
Mn (mg/kg)	29.00	20.00	20.10	-	-	-	-	-	-
Zn (mg/kg)	40.00	70.00	63.70	-	-	-	-	-	-

Amino acid profile of CSM in comparison with SBM

Amino acid	Soy-bean meal	Cotton Seed Meal						
	NRC (1994)	NRC (1994)	NCPA (2002)	Sterling et al., (2002)	Watkins et al., (2002)	Tang et al., (2012)	Sun et al., (2013)	Wang et al., (2017)
Lysine (%)	2.69	1.76	1.96	1.95	1.97	2.13	2.07	2.04
Methionine (%)	0.62	0.51	0.78	0.75	0.72	0.56	0.48	0.69
Threonine (%)	1.72	1.34	1.58	1.46	1.31	1.45	1.54	1.52

- The protein degradability of CSM is similar to that of groundnut meal, canola meal, and soybean meal for lactating dairy cows, and to that of canola meal and soybean meal for young calves.

  - Coppock, 1987

- CSM is a cheaper source of protein

Price per unit protein of commonly used Indian feed ingredients

Ingredient	CP%*	Rs/kg**	Rs per unit protein
Maize	8.75	16.50	1.88
DORB	14	12.00	0.86
CSM	40	21.00	0.52
SFC	28	28.00	1.00
Gingelly	36.1	33.00	0.91
SBM	46	32.00	0.70

*CP analysis done at NTR CVSc, SVVU, Gannavaram

**At commodity level (As per the market prices of Vijayawada, Andhra Pradesh)

CSM contains a high level of rumen-undegradable protein, compared to other conventional protein sources, which provides amino acids to the host ruminant via small intestine absorption.

- Broderick et al. 2010; Wanapat et al., 2013

Percent CP, RDP and UDP values of protein sources at rumen outflow rate of 0.05/hr

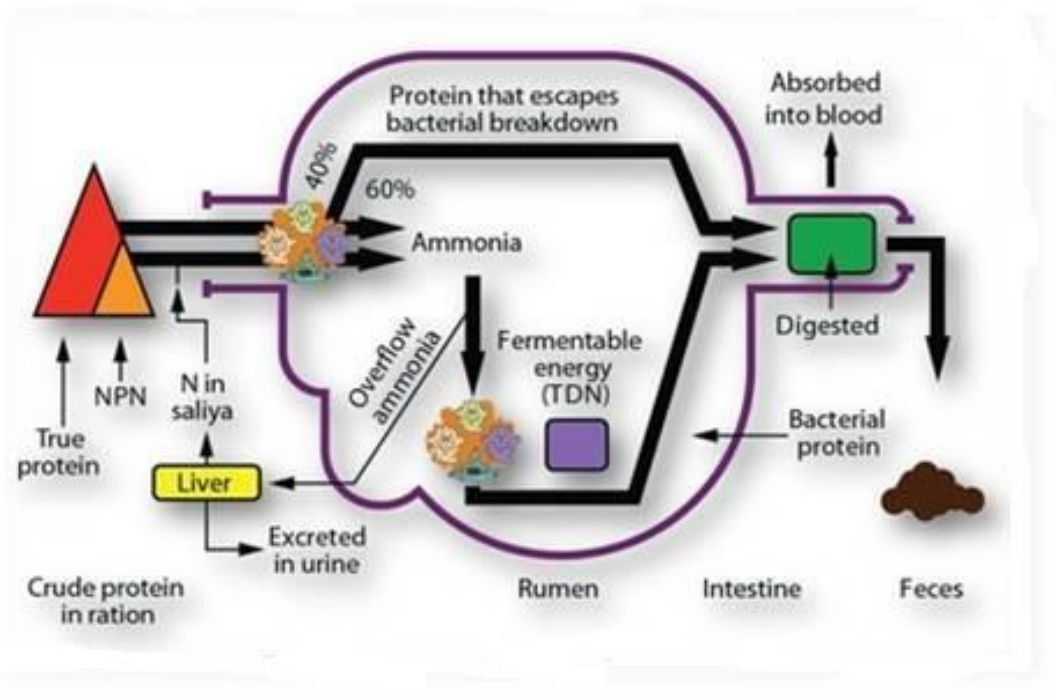
Feed Ingredient	Undegradable Protein as % of total CP					
	Ram and Gupta, 1994	Reddy and Prasad, 1985	Negi et al., 1985	Sampath and Silvaraman, 1985	NRC, 1985	Dutta et al., 1997
Ground nut C	-	70	23	32	30	30
Cotton Seed Meal	**44**	**82**	**50**	**55**	**41-50**	**35**
Niger Seed C	-	65	-	-	-	-
Sun Flower Meal	-	53	-	-	24	24
Soybean Meal	-	-	62	50	28	35
Gingelly C	-	-	-	14	-	-
Coconut C	-	-	-	81	-	-
DORB	38	-	-	-	-	25

A large scale project in China demonstrated that intensive beef production could be achieved with rice straw diets provided these were adequately supplemented with a source of **bypass protein** such as **cottonseed meal.**

-Zhang Weixian et al., 1994

An economic alternative to ruminally protected amino acids is to increase undegradable Intake Protein.

-Palmquist, 1987

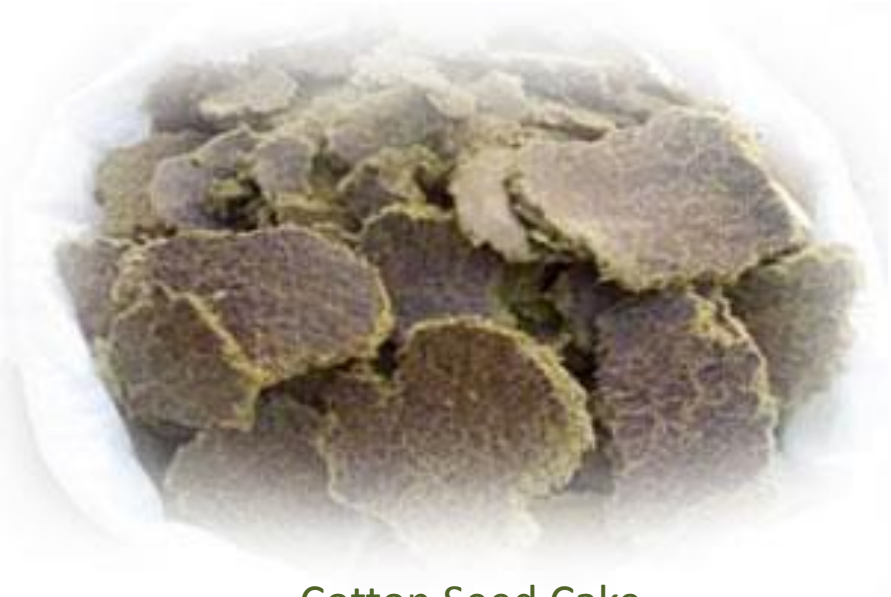


COTTON SEED MEAL
VS
OTHER COTTON SEED BY-PRODUCTS

The home-made concentrate mixture mostly used by the rural Indian dairy farmers are two ingredient based (Ground Maize and cotton seed by-products (cake or meal).

- Naik et al., 2012; 2013

Ground Maize



Cotton Seed Cake

Proximate principles of CSM in comparison with Cotton seed cake

Proximate principle / ANF	Cotton seed meal		Cotton Seed Cake					
	NRC (1994)	NCPA (2002)	Ganie et al., 2014	Aanyu et al., 2014a	Aanyu et al., 2014b	Viana et al., 2013	Kassahun et al., 2012	Jabbar et al., 2006
DM (%)	90.00	89.10	89.3	91.88	92.81	95.2	89.3	92.5
CP (%)	41.40	47.60	24.4	33.26	34.7	25.3	32.0	21.1
CF(%)	13.60	11.20	23.2	22.56	17.96	21.5	22.0	22.2
EE(%)	0.5	2.20	8.7	4.92	4.84	14.6	6.0	8.5
TA(%)	-	7.50	4.5	20.5	6.49	5.5	6.4	5.0

NCPA - National Cottonseed Products Association, 2002

- In traditional method, the cotton seeds are simply mechanically crushed without delinting / dehulling and solvent extraction, yielding 80-85% of Cake with 12-13% of crude oil.

- About 95% of the cottonseed processed in the country is through the traditional method resulting in loss of precious oil and obtainment of inferior oil cake.

- It is a wrong assumption that oil content in the CSC raises milk yield or increases fat percentage in milk; indeed higher oil content is detrimental to rumen microbes.

Estimated annual loss of cotton seed by-products due to traditional processing

(Qty: Lakh tonnes) (Value: In Rs. Lakh)

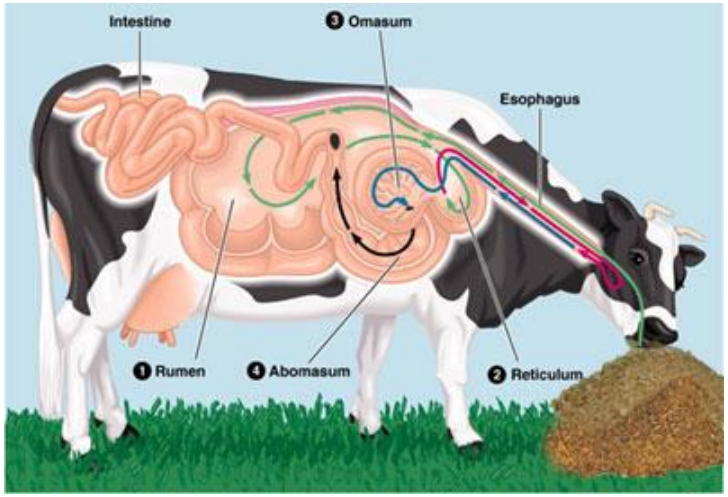
Ingredient	2013-14		2014-15		2015-16	
	Qty	Value	Qty	Value	Qty	Value
Cotton seed oil (7%)	8.34	477574	8.32	439870	6.90	405128
Linters (4%)	4.77	112195	4.64	82790	3.94	110274
Hulls (27%)	32.17	259259	31.29	233725	26.61	398896
Soap Stock (Hard) (0.8%)	0.95	4996	0.93	5590.68	0.79	4562.18
Total	46.23	854025	45.18	761976	38.24	918861

Major constraints in promoting scientific processing of cottonseed in India

- Higher capital investment required as machinery costs are quite high.
- Products obtained i.e. linters, hulls, decorticated cake, mainly depend on export market; hence, price keep varying as well as income.
- Local market has more demand for un-decorticated cake.
- Lack of proper Government support.
- Prices of the products obtained keep on varying depending on the demand and prices of competing products and therefore price realisation keep on varying which is again a deterrent for investment in this sector.

- Central Institute for Research on Cotton Technology (CIRCOT) (ICAR)

In Ruminants



- Although gossypol is much less toxic to ruminants, CSC use is limited in mature and non-reproductive animals.

- Generally, cottonseed meal can be safely included up to 15% in cattle diets - (NDDB, 2012)

- Due to incomplete rumen development, calves are susceptible to gossypol toxicity. Recommended CSM inc. @ 10-15% in calves under 5 months old. - (Gohl, 1982)

Feeding tropical dairy cattle with local protein and energy sources for sustainable production

- Wanapat et al., 2017

-Journal of Applied Animal Research
DOI: 10.1080/09712119.2017.1288627

Feed formulation of the dietary treatments

Wanapat et al., 2017

Ingredients %	Formulation I	Formulation II
Cassava Chip	55.2	66.5
High protein concentrate	-	33.5
Rice bran	10.2	-
Soybean meal	12.4	-
Brewers' grain	7.2	-
Palm kernel cake	5.8	-
Coconut meal	4.4	-
Urea	1.5	-
Molasses	1.5	-
Salt	0.5	-
Sulphur	0.3	-
Mineral Premix	1.0	-

Sixty cross bred dairy cows alloted to 2 groups :
Group I fed with **SBM (@ 12.4%)** based local conc. Mixture used by thai farmers along with adlibitum Ruzi grass.
Group II fed with **CSM (@ 28.9%)** based experimental conc. Mixture along with adlibitum Ruzi grass.

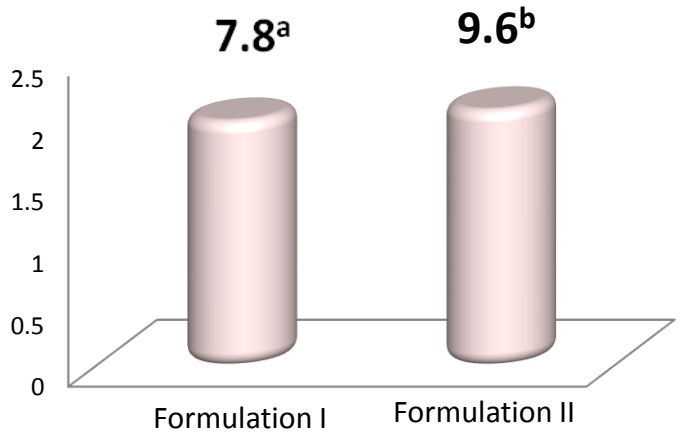
Effect of Formulation II on the intake, digestion coefficients and production parameters in lactating dairy cross breeds

Wanapat et al., 2017

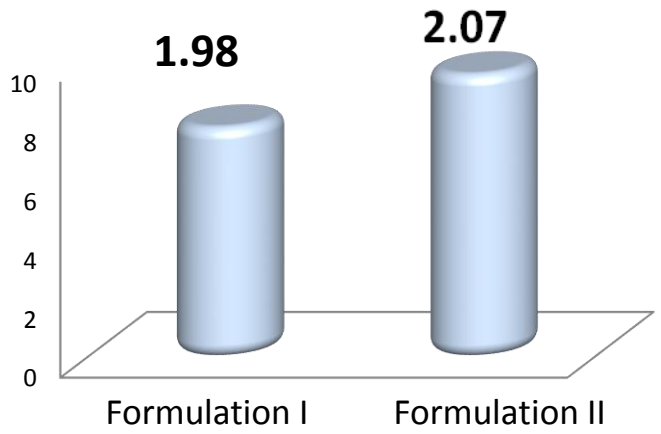
Items	Formulation I	Formulation II	SEM
Voluntary daily intake			
Roughage	7.1	7.2	0.33
Concentrate	6.6[a]	8.0[b]	0.67
Digestion coefficients			
OM	69.2[a]	75.8[b]	1.21
CP	52.3[a]	58.5[b]	1.14
NDF	54.5[a]	59.4[b]	2.05
ADF	50.8[a]	53.1[b]	1.02
Milk production			
Milk yield (kg/head/day)	13.3[a]	16.2[b]	0.92
3.5% FCM (kg/head/day)	13.9[a]	16.9[b]	0.60

Effect of Formulation II on economical return in lactating dairy cross breeds (US dollars/cow/day)

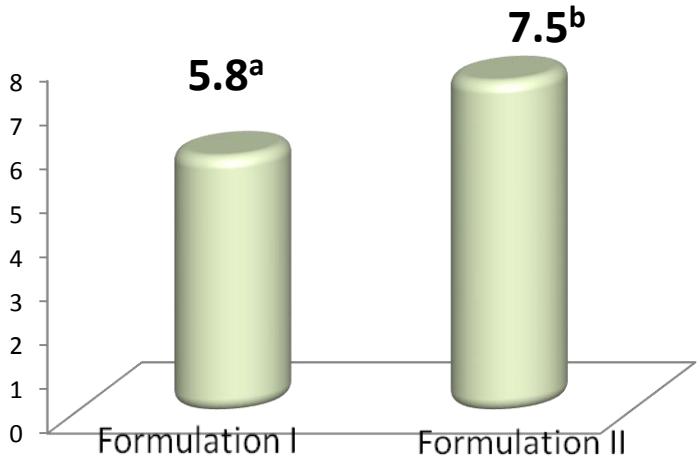
MILK INCOME



FEED COST



NET PROFIT



Replacement of soybean meal by cottonseed meal in diets based on spineless cactus for lactating cows

- Slva et al., 2009

-Revista Brasileira deZootecnia, 38(10): 1995-2000

Ingredient composition according to soybean meal replacement levels by cotton seed meal in the experimental diets

(Silva et al., 2009)

Ingredients (% DM)	Soybean meal replacement level (%)				
	0	25	50	75	100
Cactus pear	53.0	53.0	53.0	53.0	53.0
Sorghum Silage	32.0	32.0	32.0	32.0	32.0
Soybean meal	13.0	10.00	6.00	3.00	0.00
Cotton seed meal	0.00	3.00	6.00	9.00	12.0
Urea	0.75	0.84	1.03	1.12	1.31
Mineral mixture	1.24	1.24	1.24	1.24	1.24

Five lactating Girolando cows fed a diet containing 53% cactus pear and 32% Sorghum silage with CSM incorporation @ 0,3,6,9, and 12 (Replacing SBM) - SBM incorporated @ 13, 10, 6, 3 and 0 levels in T1, T2, T3, and T4, respectively.

Effect of CSM inclusion (substituting SBM) on nutrient digestibilities and production performance

(Silva et al., 2009)

Item	SBM replacement level (%)					CV (%)
	0	25	50	75	100	
Nutrient digestibility coefficients						
OM	59.84	57.44	58.99	59.63	60.75	7.70
CP	49.17	43.10	47.54	50.77	50.12	12.91
NDF	31.95	28.87	28.07	32.15	33.71	25.01
Total CHO	55.03	53.08	55.83	54.14	55.50	11.08
Milk yield and components						
M. yield (kg/d)	11.43	11.82	11.73	11.40	11.36	3.99
4% FCMY (kg/d)	11.54	11.56	11.69	10.81	11.46	8.69
T. Solids (%)	12.87	12.71	12.87	12.40	12.80	3.93
Protein (%)	3.47	3.46	3.43	3.34	3.41	3.00

** (P>0.05)*

CSM can replace 100% SBM with out any adverse effects on nutrient digestibility and production performance

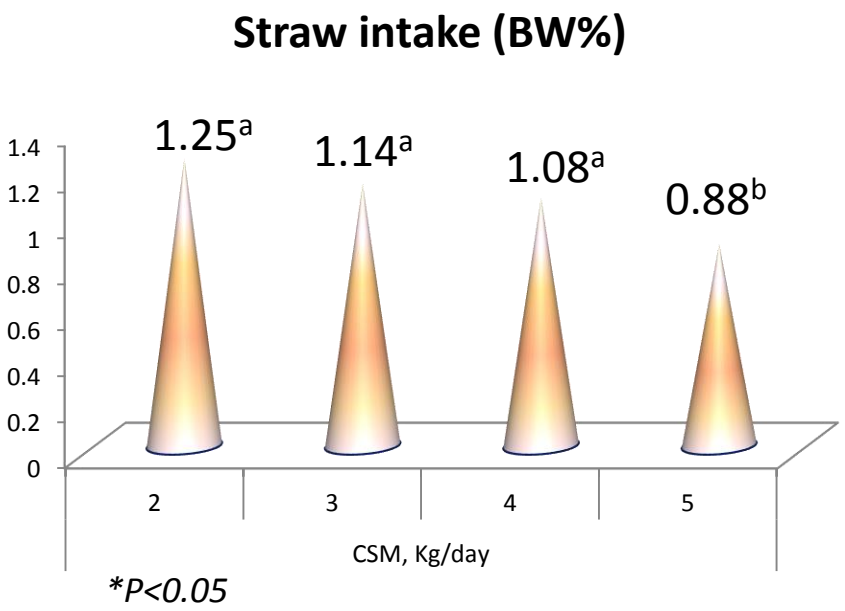
Cottonseed meal supplementation of dairy cattle fed rice straw

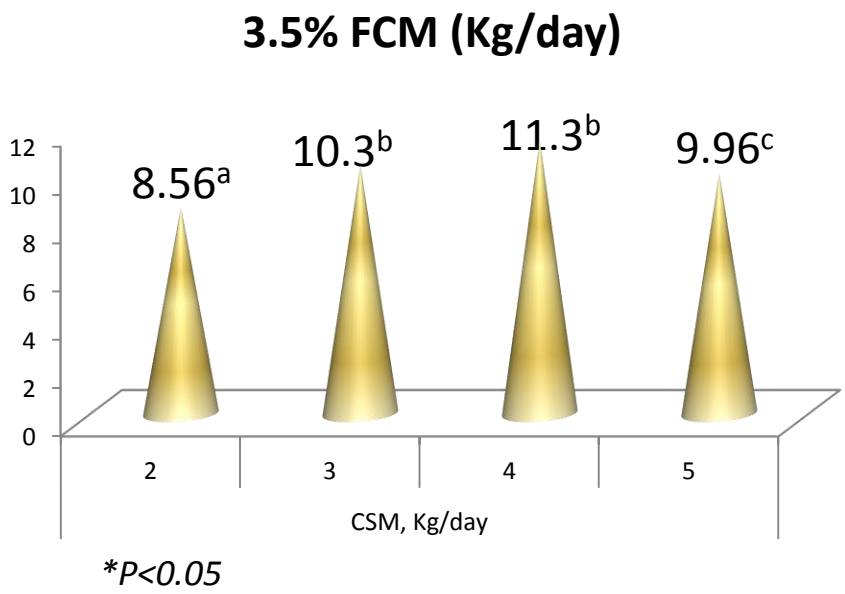
- Wanapat et al., 1996

- Livestock Research for Rural Development 8 (3): 1 - 8

Effect of CSM supplementation on rice straw intake, milk yield and milk components

Wanapat et al., 1996





28 multiparous zebu cattle fed with 4 levels of cottonseed meal (CSM@ 2, 3, 4, 5 kg/head/day) in diets based on *ad libitum* rice straw and cassava chips (5 kg/head/day)

Results :

- Decreased Intake ($P<0.05$).
- Increased Milk production ($P<0.05$) and unaltered milk components.

Recommended level of CSM supplementation : 4 kg/head/day

Effect of Level of Crude Protein and Use of Cottonseed Meal in Diets Containing Cassava Chips and Rice Straw for Lactating Dairy Cows

- Promkot and Wanapat, 2005

- Asian-Australasian Journal of Animal Science 18(4): 502-511

Ingredients composition of the experimental concentrates

Promkot and Wanapat, 2005

Ingredients (% DM)	Cotton seed meal concentration (% Dry matter)			
	0	20	25	30
Cassava chip	58.5	54.8	52.6	50.0
Cotton seed meal	0	20.1	24.8	29.6
Soyabean meal	14.1	0.0	0.0	0.0
Rice bran	9.4	8.5	8.0	7.5
Broken rice	6.6	6.5	6.1	4.9
Molasses	3.7	3.9	3.9	3.2
Urea	2.5	2.6	2.6	2.6
Sulphur	0.5	0.5	0.5	0.5
Dicalcium	0.7	0.7	0.7	0.7
Salt	0.1	0.1	0.1	0.1
Mineral mixture	0.6	0.6	0.6	0.6
Tallow	3.3	1.8	0.3	0.2

Effect of CSM supplementation on rice straw intake, milk yield and milk components

Promkot and Wanapat, 2005

Item	CSM Incorporation level (%)				SEM
	0	20	25	30	
Intake					
DMI	6.0	6.2	6.6	7.2	0.3
OMI*	5.8[a]	5.9[a]	6.4[b]	6.8[b]	0.2
CPI**	0.7[a]	0.8[a]	1.0[b]	1.2[c]	0.1
Milk yield and components					
M. yield (kg/d)	10.7	11.5	11.6	11.6	0.3
4% FCMY (kg/d)	11.1	11.8	11.7	11.8	0.6
Economic returns					
Feed cost	1.11	0.93	1.03	1.13	6.3
US $/hd/d	1.66	1.98	2.00	2.09	5.3
US $/kg milk	0.15	0.17	0.17	0.16	0.2

**P<0.05 **P<0.01*

Thirty cows fed with TMR with Conc. (Cassava chips, SBM or CSM):R (chopped rice straw)@ 60:40) *adlibitum*

Increasing dietary CP levels from 10.5 to 13.8% by the addition of CSM was beneficial to cows during mid lactation

Replacing soybean meal with high energy cottonseed meal in diets for dairy yielding cows: intake, nutrient digestibility, nitrogen efficiency and milk yield

- Alves et al., 2010

- Revista Brasileira deZootecnia, 39(3): 532-540

Ingredients composition of the experimental concentrates

Alves et al., 2010

Ingredients (% DM)	Cotton seed meal concentration				
	0	8.7	17.4	26.1	34.8
Corn Silage	60.0	60.0	60.0	60.0	60.0
Soybean meal	13.70	11.65	9.59	7.54	5.48
Cotton seed meal	0.00	3.48	6.96	10.44	13.92
Maize	24.9	23.41	23.44	21.97	20.50
Urea sulfate	0.60	0.63	0.68	0.73	0.78
Mineral mixture	0.80	0.83	0.80	0.80	0.80

Five crossbred Holstein × Gir cows fed a diet containing 60% corn silage with CSM replacing SBM@ 0, 15, 30, 45 and 60 percentage, respectively.

Effect of CSM inclusion (substituting SBM) on nutrient digestibilities and production performance

Alves et al., 2010

Item	SBM replacement level (%)					CV (%)
	0	8.7	17.4	26.1	34.8	
Nutrient digestibility coefficients						
OM	61.45	67.73	64.42	63.16	66.28	8.67
CP	64.38	63.39	61.62	61.64	64.67	15.71
NDF	36.42	46.64	43.29	40.53	39.43	29.64
Total CHO	60.81	67.27	64.66	61.90	64.99	8.20
Milk yield and components						
M. yield (kg/d)	14.73	13.28	14.49	14.44	13.20	18.46
3.5% FCMY (kg/d)	15.30	13.90	15.03	15.04	14.14	22.45

** (P>0.05)*

CSM can replace 34.8% SBM with out any adverse effects on nutrient digestibility and production performance

Replacement of soybean meal by cottonseed meal 38% in multiple supplements for grazing beef heifers

- Barros et al., 2011

- Revista Brasileira deZootecnia, 40(4): 852-859

Percentage composition of supplements, based on natural matter

Barros et al., 2011

Ingredients (%)	Supplement				
	MM	CS_0	CS_{33}	CS_{67}	CS_{100}
Mineral mixture	100.0	6.0	6.0	6.0	6.0
Ground sorghum grain	-	20.5	20.5	20.5	20.5
Ground corn grain	-	20.5	20.5	20.5	20.5
Soybean meal	-	50.0	33.5	16.5	-
Cotton seed meal	-	-	16.5	33.5	50.0
Urea/SA (9:1)	-	1.0	1.5	2.5	3.0
Wheat meal	-	2.0	1.5	0.5	-

Twenty five Nellore heifers & 10 crossbred heifers fed *Brachiaria decumbens* pasture based diets supplemented with CSM replacing SBM @ 0, 33, 67, and 100% levels (CS_0, CS_{33}, CS_{67}, and CS_{100}, respectively).

Effect of CSM inclusion (substituting SBM) on growth performance of heifers

Barros et al., 2011

Item	Supplement					CV (%)
	Control	CS_0	CS_{33}	CS_{67}	CS_{100}	
Intial Body weight (Kg)	251.1	249.2	251.1	248.0	249.7	2.5
Final Body weight (Kg)	283.0	295.7	297.7	293.9	295.4	2.7
Avg. daily wt. gain (gms)	397	546	570	525	542	18.4

** (P>0.05)*

Effect of CSM inclusion (substituting SBM) on digestibility coefficient of nutrients

Barros et al., 2011

Item	Supplement					CV (%)
	Control	CS_0	CS_{33}	CS_{67}	CS_{100}	
OM	64.98	63.35	62.76	65.68	66.78	4.1
CP	46.66	49.39	49.91	56.15	57.16	9.7
EE	75.24	75.80	74.86	74.73	75.43	1.9
NFC	58.15	61.80	66.29	64.85	70.31	5.9
TDN	63.91	64.77	64.39	65.74	66.36	3.2

** (P>0.05)*

The use of cottonseed meal 38% in multiple supplements for heifers substituting the soybean meal result in the same productive performance and nutrient digestibilities

Evaluation of cottonseed oil-cake meal as a protein source in calf starter meals

- Bangani et al., 2000

- South African Journal of Animal Science 30(1): 67-69

Composition of the ingredients used in Calf starter meal

Bangani et al., 2000

Ingredients (Kg)	Calf Starter meal	
	CSM	SBM
Ingredients (Kg)		
Lucerne hay	86	82
Wheat	610	565
Maize	150	200
CSM	**80**	-
SBM	-	**80**
Fish meal	63	63
Limestone	6	5
Salt	5	5
Chemical composition (% of DM)		
CP	18.9	19.0
CF	7.6	7.0
TDN	80.5	81.4

Growth performance of the Jersey and Holstein cows (14 days aged) fed with CSM or SBM based calf starter diets

Bangani et al., 2000

Item	Calf starter meal		SEM
	CSM	SBM	
Jersey Calves			
Intial wt (Kg)	21.8	21.1	0.47
Final wt (Kg)	54.6	55.2	2.00
ADG	0.43	0.44	0.22
DMI/day	72.7	76.8	3.00
EFC (Kg/Kg DMI)	0.469	0.464	0.02
Holstein Calves			
Intial wt (Kg)	32.8	30.5	1.42
Final wt (Kg)	67.6	64.0	2.2
ADG	0.66	0.65	0.03
DMI/day	1.18	1.20	0.06
EFC (Kg/Kg DMI)	0.58	0.54	0.35

CSM can be successfully incorporated @ 8% (replacing 100% SBM) in the calf starter diet without any negative effects on the calve's (with 14 days age) growth performance

The effect of formaldehyde treatment of solvent and mechanical extracted cottonseed meal on the performance, digestibility and nitrogen balance in lambs

- Khan et al., 2000

- Asian-Australasian Journal of Animal Science 13(6): 785-790

Ingredients (%) of the experimental rations

Khan et al., 2000

Ingredients (%)	Rations			
	A	B	C	D
CSM (Solvent extracted)	40.00 UT	40.00 FT	-	-
CSM (Mechanically extracted)	-	-	40.00 UT	40.00 FT
Maize	15.00	15.00	15.00	15.00
Wheat bran	8.00	8.00	8.00	8.00
Molasses	10.00	10.00	10.00	10.00
Salt	1.00	1.00	1.00	1.00
Premix	1.00	1.00	1.00	1.00
Wheat straw	25.00	25.00	25.00	25.00

UT – Un treated; FT – Formaldehyde treated

A- CSM Solvent extracted – untreated; B – CSM Solvent extracted – HCHO treated; C – CSM Mechanically extracted – Untreated; D - C – CSM Mechanically extracted – HCHO treated

Growth Performance and nitrogen retention lambs fed on untreated and formaldehyde treated CSM based rations

Khan et al., 2000

Item	Rations				SE
	A	B	C	D	
Growth performance					
Intial wt. (kg)	20.65	20.85	21.75	21.30	-
Final wt. (kg)	35.05	37.10	36.71	38.22	-
Avg. wt. gain (g/d)	160^{a}	180^{b}	166^{a}	188^{b}	2.45
Avg. DMI (g/d)	1436^{a}	1567^{b}	1475^{a}	1587^{b}	8.05
Feed: gain ratio	8.97^{b}	8.72^{b}	8.77^{b}	8.02^{a}	0.12
Digestibility Coefficients					
DM	68.92^{a}	71.21^{b}	70.42^{a}	73.46^{b}	0.76
CP	75.41^{a}	76.16^{b}	74.64^{a}	77.10^{b}	0.46
CF	57.64^{a}	59.22^{b}	56.88^{a}	60.79^{b}	0.48
Retained Nitrogen					
% intake	20.88^{a}	22.12^{b}	19.30^{a}	24.80^{b}	1.99
% absorbed	27.53^{a}	29.57^{b}	25.76^{a}	32.72^{b}	1.69

** ($P<0.05$)*

Oil extraction methods of CSM did not alter their meal utilization in lambs, however, HCHO (0.3%) treatment of meals enhanced the growth, digestibility and nitrogen retention in lambs fed total mixed rations

Improving the Nutritive Value of Cottonseed Meal by Adding Iron on Growing Lambs Diets

- Ward et al., 2008

-World Journal of Agricultural Sciences 4(5): 533-537

Ingredient (%) composition of the experimental rations

Ward et al., 2008

Item	SI	II	III
Corn	35.5	30.0	30.0
Soybean meal	13.0	---	---
Cotton seed meal	---	30.0	30.0*
Wheat bran	16.7	---	----
Wheat straw	6.5	11.2	11.2
Berseem hay	25.0	25.0	25.0
Minerals	0.2	0.2	0.2
Vitamins	0.1	0.1	0.1
Salt	0.1	1.0	1.0
Limestone	1.0	2.5	2.5

* CSM supplemented by 15 gms ferrous sulfate/kg

I – SBM@13% of conc. mixture; II - CSM@ 30% of conc. mixture; III – CSM@ 30% of conc. mixture + 1.5 gms ferrous sulfate/1 kg

Growth Performance and nitrogen retention lambs fed on untreated and formaldehyde treated CSM based rations

Ward et al., 2008

Item	Rations			SE
	I	II	III	
Growth performance				
Intial wt. (kg)	25	23	27	-
Final wt. (kg)	55	48.5	55.5	-
Avg. wt. gain (g/d)	200^{b}	170^{a}	190^{b}	3.50
Avg. DMI (g/d)	1000	1100	1110	9.20
FCR, g feed/g gain	5.00	6.47	5.84	0.15
Digestibility Coefficients				
OM	80.0	68.3	75.0	1.67
CP	73.0	60.0	70.3	1.76
CF	53.3	44.3	53.0	1.21
Nitrogen Balance (g/head/day)	6.4^{b}	4.1^{a}	6.2^{b}	0.98

** ($P<0.05$)*

Oil extraction methods of CSM did not alter their meal utilization in lambs, however, HCHO (0.3%) treatment of meals enhanced the growth, digestibility and nitrogen retention in lambs fed total mixed rations

Supplementation of cottonseed meal on feed intake, digestibility, live weight and carcass parameters of Sidama goats

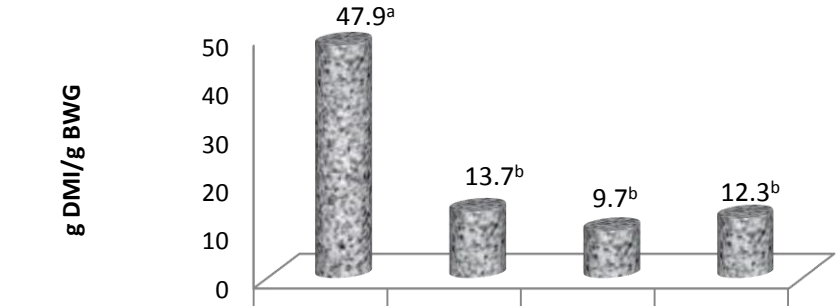
- Solomon et al., 2008

- Livestock Science 119: 137–144

Growth performance of Sidama goats fed grass hay supplemented with different levels of cottonseed meal

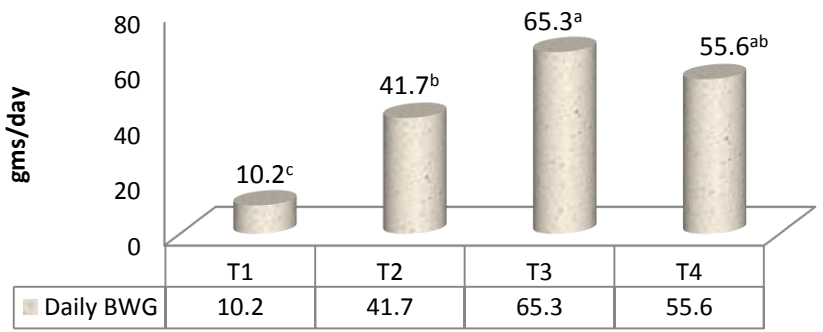
Solomon et al., 2008

FCR (g DMI/g BWG)



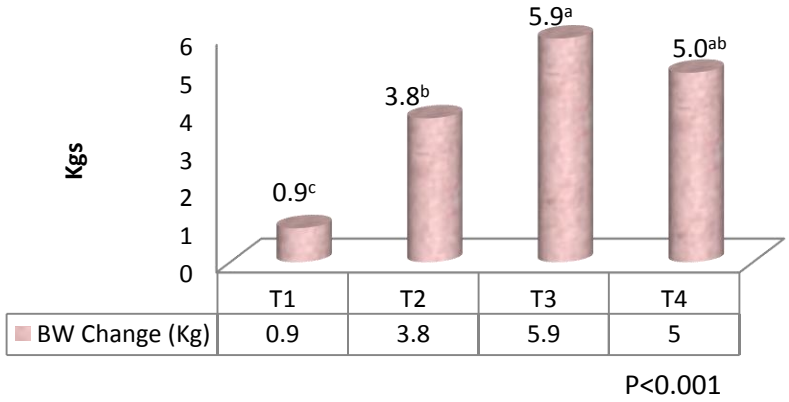
*P<0.01

Daily BWG (gms/day)



*P<0.01

BW Change (Kg)



P<0.001

T1 – Sole grass hay; T2 – Grass hay + 200 g DM CSM; T3 – Grass hay + 300 g DM CSM; T4 – Grass hay + 400 g CSM

Carcass characteristics of Sidama goats fed grass hay supplemented with different levels of cottonseed meal

Solomon et al., 2008

Item	Rations				SE
	T1	T2	T3	T4	
Heart**	65^{b}	85^{ab}	99^{a}	89^{b}	3.85
Head**	1081^{b}	1298^{ab}	1409^{a}	1324^{ab}	54.08
Liver*	251^{b}	316^{ab}	361^{a}	362^{a}	18.87
Kidney**	53^{b}	64^{ab}	72^{a}	72^{a}	3.89
Kidney Fat***	12^{b}	64^{a}	78^{a}	70^{a}	4.12
Reticulo rumen	428	405	459	369	24.58
Omaso-abomasum**	123^{b}	129^{ab}	155^{a}	119^{b}	5.37
Intestine	491	598	567	561	37.74
Abdominal fat***	108^{c}	343^{b}	662^{a}	450^{b}	30.56
Testis**	128^{b}	169^{ab}	194^{a}	186^{a}	10.35
Blood*	867^{b}	986^{ab}	1061^{a}	979^{ab}	40.82
Total edible Offals**	7312^{b}	9866^{a}	10925^{a}	10371^{a}	421.63

(*P<0.05; **P<0.01; P<0.001)

it is concluded that supplementation of CSM at 300 gm DM per day resulted in better animal performance parameters in Sidama goats


THANK YOU