More Almond Hulls for California Dairy Cows?

california almonds®
Almond Board of California

Session Speakers

Karen Lapsley, ABC

Ed DePeters, UC Davis

Jed Asmus, January Innovations, Inc.

Feeding High Amounts of Almond Hulls (AH) to Lactating Cows

Ed DePeters & Jed Asmus
University of California at Davis

January Innovations

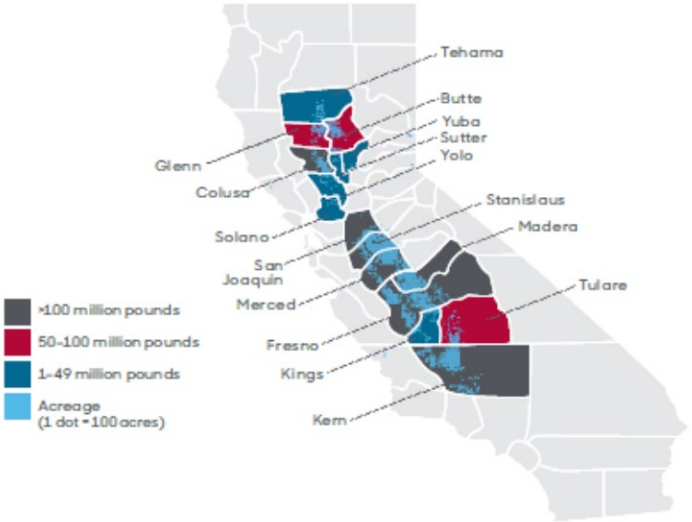
Team Effort

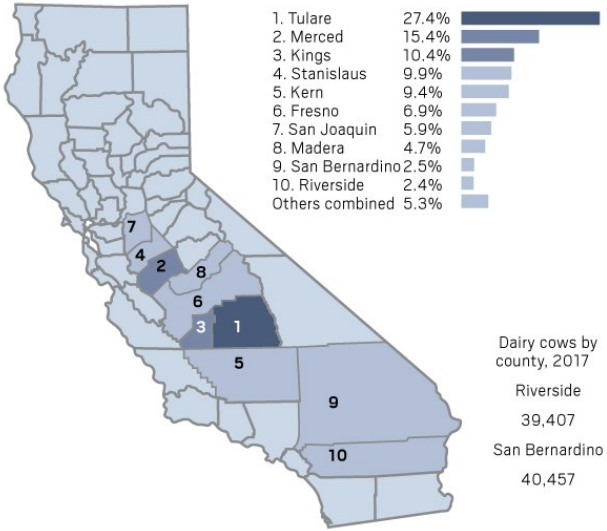
- Almond Board CA
  (Mr. Guangwei Huang & Dr. Karen Lapsley)
- Jed Asmus, January Innovations (ARPAS)
- Jennifer Heguy, UC Cooperative Extension (ARPAS)
- UC Davis
  - Hannah Bill (technician)
  - Katie Swanson (postdoctoral)
  - Staff at Dairy Facility & Feed Mill
  - Student Interns

CA: **#1** Almond & **#1** Milk State

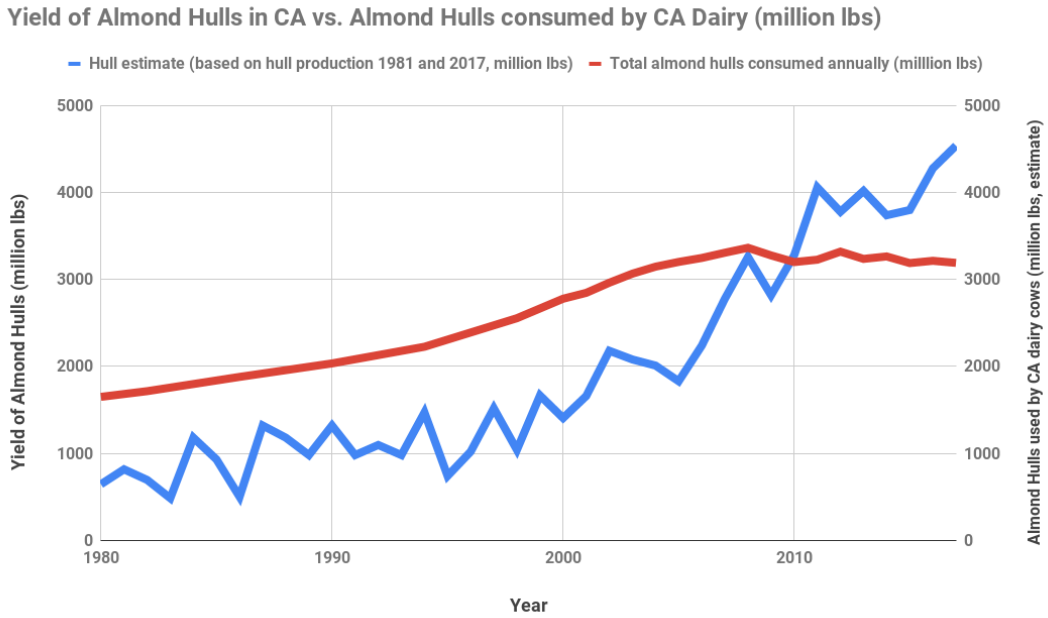
- 1,000,000 bearing acres
- 330,000 nonbearing acres
- 1.14 million tons (shelled)

- 1,749,000 milk cows
- 1,300 dairy farms
- 40 billion lb milk





Projected AH Quantity & Dairy Cow Consumption



Milk cows in CA fed 5 lb As Fed almond hulls

Objectives

- Evaluate the possibility of feeding **high amounts** of almond hulls to lactating cows.
- Determine the impact of foreign material, shells and sticks, on the quality (chemical composition & digestibility) of almond hulls.

Approaches

- **Lactation study**
- Commercial versus Pure AH
  - *In sacco* disappearance in 2 ruminally fistulated, dry, dairy cows
  - *In vitro* rumen fermentation gas production
  - *In vitro* DM and NDF digestibility (‘Daisy’)
  - Chemical composition
- AH feeding survey of nutritionists

Lactation Study

- 12 lactating Holstein cows (96 DIM)
  - 4 1st , 4 2nd, 4 3rd lactation cows
- Treatments: 0, 4, 8, or 12 lb AH/cow
- Production performance: milk yield, milk composition & component yield, feed intake, and diet digestibility.

Statistical Design

Replicated 4 x 4 Latin Square

21 day periods

	Cows			
Parity 1	1	2	3	4
Parity 2	5	6	7	8
Parity 3	9	10	11	12
Period 1				
Period 2				
Period 3				
Period 4				

0 lb AH | 4 lb AH | 8 lb AH | 12 lb AH

Ingredient Composition of TMR (lb/cow)

Ingredient	0 lb AH	4 lb AH	8 lb AH	12 lb AH
Almond hulls	0	4	8	12
Alfalfa hay	23.3	23.3	23.3	23.3
Corn, flaked	20.9	19.3	18.2	15.0
Soy hulls	6.9	4.7	1.2	0
Wheat hay	2.0	1.5	1.5	1.5
Soybean meal	0.9	1.1	1.7	2.3
DDG	3.8	3.8	3.8	3.8
Cottonseed	2.3	2.3	2.3	2.3
Minerals	1.4	1.4	1.4	1.4

Based on average intake of 61.5 lb

Composition of Almond Hulls

Item	Mean	SD	Minimum	Maximum
CF, %	14.85	1.77	13.80	17.50
Lignin, %	7.16	0.78	6.33	8.09
CP, %	4.45	0.24	4.20	4.70
EtOH CHO, %	32.03	2.16	29.70	34.10
H_2O CHO, %	34.65	2.24	31.80	37.20
aNDF, %	23.83	2.04	22.20	26.60
aNDFom,%	23.53	2.08	21.90	26.40
ADF, %	14.88	2.17	12.90	16.80
ADFom,%	14.00	2.35	11.50	16.10
Ash, %	5.91	0.33	5.63	6.31

CF As Is basis = 12.78%

N = 4 samples

Summary Production

Item (lb/d)	0 lb AH	4 lb AH	8 lb AH	12 lb AH
DM Intake, lb/d	58.7	60.1	58.1	58.6
Milk, lb/d	85.4	86.5	81.2	82.9
ECM, lb/d	92.0	92.8	88.2	90.2
Fat, lb/d	3.21	3.23	3.17	3.26

Summary Production

Item (lb/d)	0 lb AH	4 lb AH	8 lb AH	12 lb AH
Milk, lb/d	85.4	86.5	81.2	82.9
Fat, %	3.81[a]	3.78[a]	3.95[b]	3.97[b]
Protein, %	3.46[a]	3.43[a]	3.35[b]	3.33[b]
Solids, %	12.58	12.58	12.65	12.64

Feed (DM) Intake

Feed (lb/d)	0 lb AH	4 lb AH	8 lb AH	12 lb AH
Parity 1	52.4	55.4	52.7	56.0
Parity 2	57.0	57.3	55.4	55.9
Parity 3	66.5	68.9	65.7	63.5
Overall	58.7	60.1	58.1	58.6

Milk Yield – Actual

Milk (lb/d)	0 lb AH	4 lb AH	8 lb AH	12 lb AH
Parity 1	73.5	77.8	69.5	74.8
Parity 2	81.2	81.4	76.3	78.5
Parity 3	98.8	100.5	97.5	95.5
Overall	85.4	86.5	81.2	82.9

Diet P < 0.08

Milk Yield – Energy Corrected

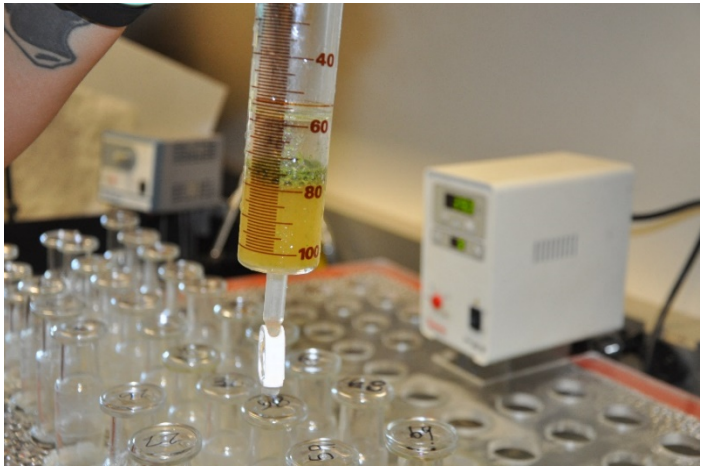
ECM (lb/d)	0 lb AH	4 lb AH	8 lb AH	12 lb AH
Parity 1	82.1	84.7	75.9	81.6
Parity 2	88.2	87.6	86.0	88.2
Parity 3	103.2	106.0	103.0	100.8
Overall	92.0	92.8	88.2	90.2

Energy-Corrected Milk accounts for volume and energy content of each milk component. Puts everything on an equal basis.

Summary Digestibility
% Apparent Total Tract

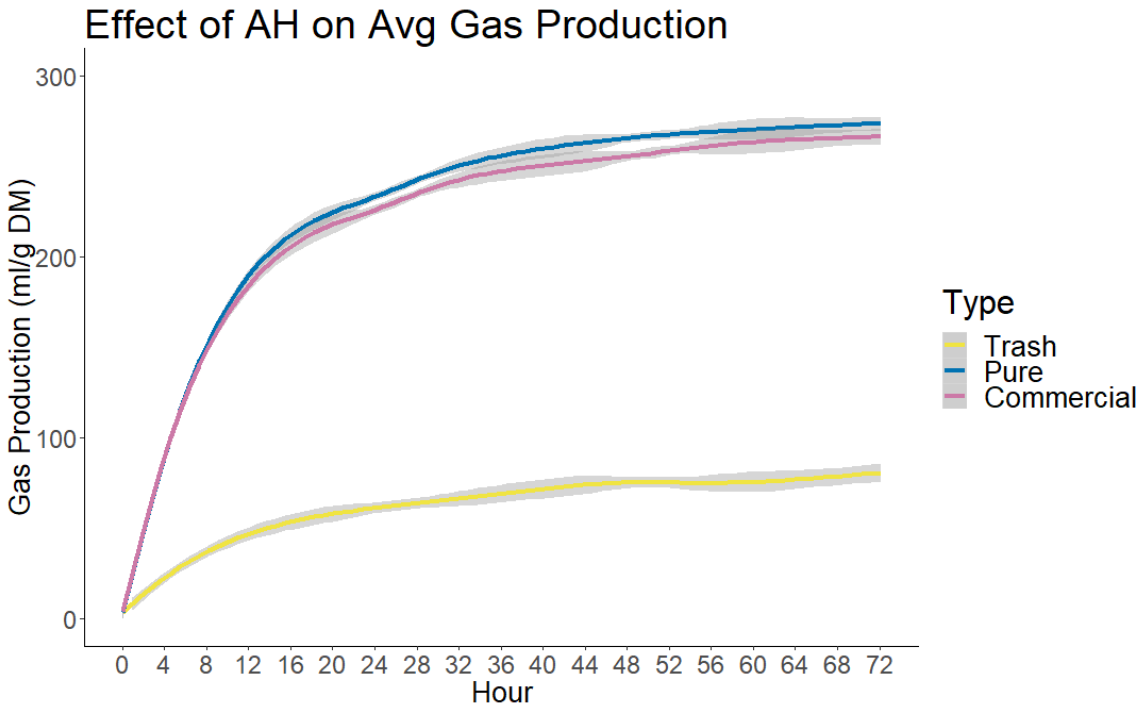
Item	0 lb AH	4 lb AH	8 lb AH	12 lb AH
DM, %	69.1[a]	72.8[bc]	72.2[ab]	75.1[b]
aNDF, %	47.5	51.4	49.0	52.9
aNDFom,%	47.9[a]	52.6[b]	50.5[ab]	51.6[ab]
ADF, %	41.6[a]	43.5[ab]	43.4	46.9[b]
ADFom, %	42.2	44.2	43.1	46.4
CP, %	66.2[a]	68.1[ab]	66.8[ab]	70.0[b]

Approaches



- **Commercial versus Pure AH**
  - ***In vitro* rumen fermentation gas production**
  - ***0, 2, 4, 6, 8, 10, 22, 24, 26, 28, 30, 46, 50, 52, 54, 72 h* (16 times points)**
  - **Rate & Extent of digestion**
  - **Energy estimate**

In Vitro Gas Production



Extent: Pure (270 ml) > Commercial (268 ml) > Trash (79 ml)
Rate: Pure = Commercial (10%/h) > Trash (7%/h)

Field Weight Yields

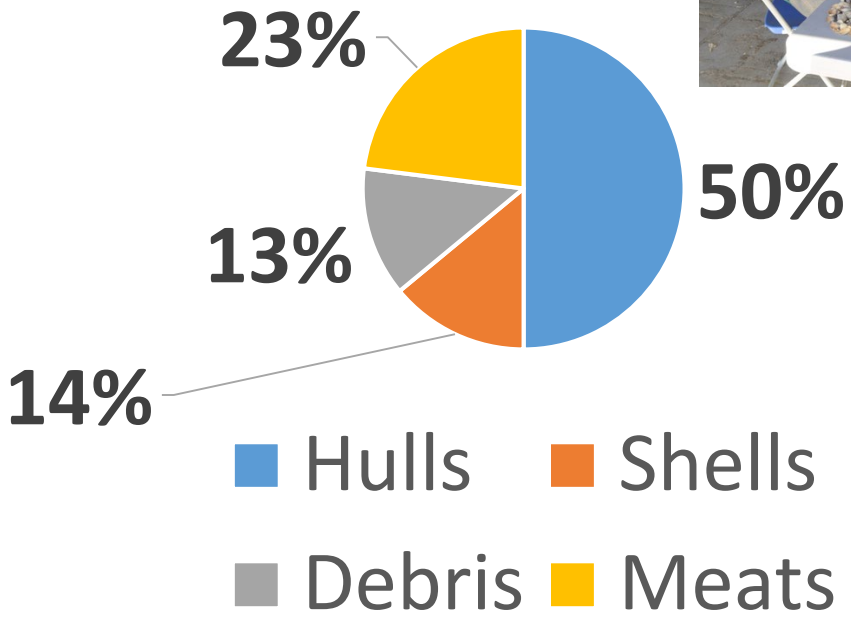


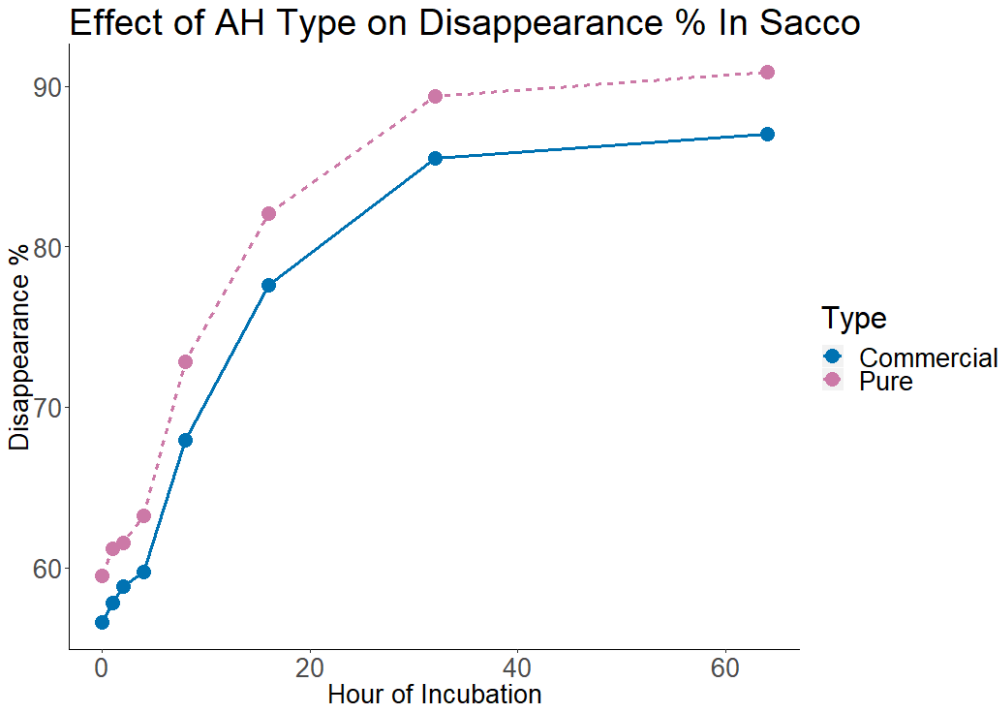
Figure is from Environmental Protection Agency. Food & Agricultural Industry 2017

5 Nonpariel AH (4.7% debris) 7 Other Variety (6.8% debris)

Approaches

- **Commercial versus Pure AH**
  - ***In sacco* "disappearance" in 2 ruminally fistulated, dry, d**
  - ***0, 1, 2, 4, 8, 16, 32, 64 h***
  - ***Rate & Extent of disappearance***

In Sacco Dry Matter Disappearance



Extent: Pure > Commercial. **Rate: Pure (7.8%/h) > Commercial (5.5%/h)**

How will a nutritionist use the data to feed cows?


VOLVO
KUHN
KNIGHT

“Thank You”

Almond Board of CA
- Biomass Workgroup
(almond handlers & growers)

THE END !!

QUESTIONS ??

Almond Hulls as Feed:
Current knowledge and future questions

Jed Asmus, M.S., PAS

January Innovation Inc.

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Almond Board of California

The Current State of Affairs.

- Almond hulls (AH), are considered to be a by-product feed stuff by the feed industry
- In California, AH are primarily consumed by dairy cattle and growing animals as a pseudo forage / concentrate
- Bulk density of AH limit their transport to other feeding centers domestically and internationally due to the increased freight cost.
- Commercial AH are graded either as “prime” or “not-prime” by a 15% crude fiber max.
- California cows are feed on average 5 lbs. per head per day (3-8 range) (Based on Heguy et. Al 2018 survey)

The Last 3 Years in retrospect

Feed Codes:	ALMOND HULLS
# of Samples:	571
Date Range:	1/1/2017 To 12/3
Region:	West

ANALYSIS RESULTS
Dry Matter (%DM)
Moisture (%DM)
PROTEINS
Crude Protein (%DM)
Adjusted Protein (%DM)
Soluble Protein (%CP)
ADF Protein (ADICP) (%DM)
NDF Protein (NDICP) (%DM)
FIBER
Acid Detergent Fiber (%DM)
Neutral Detergent Fiber (%DM)
Crude Fiber (%DM)
Lignin (%DM)
Lignin / NDF Ratio
NDF 30 HR Digestibility (%NDF)
CARBOHYDRATES
Ethanol Soluble CHO (Sugar) (%(
Starch (%DM)
Crude Fat (%DM)
MINERALS
Ash (%DM)
Calcium (%DM)
Phosphorus (%DM)
Magnesium (%DM)
Potassium (%DM)
Sulfur (%DM)
Sodium (%DM)
Chloride (%DM)
Iron (PPM)
Manganese (PPM)
Zinc (PPM)
Copper (PPM)
DCAD (meq/100gdm)
FERMENTATION
ENERGY & INDEX CALCULATIONS
Non Structural Carbohydrates
TDN (%DM)
Net Energy Lactation (mcal/lb)
Net Energy Maintenance (mcal/lb
Net Energy Gain (mcal/lb)
Non Fiber Carbohydrates (%DM)
Non Structural Carbohydrates (%

Feed Codes:	ALMOND HULLS
# of Samples:	412
Date Range:	1/1/2018 To 12/31/2018
Region:	West

ANALYSIS RESULTS
Dry Matter (%DM)
Moisture (%DM)
PROTEINS
Crude Protein (%DM)
Adjusted Protein (%DM)
Soluble Protein (%CP)
ADF Protein (ADICP) (%DM)
NDF Protein (NDICP) (%DM)
FIBER
Acid Detergent Fiber (%DM)
Neutral Detergent Fiber (%DM)
Crude Fiber (%DM)
Lignin (%DM)
Lignin / NDF Ratio
NDF 30 HR Digestibility (%NDF)
CARBOHYDRATES
Ethanol Soluble CHO (Sugar) (%DM)
Starch (%DM)
Crude Fat (%DM)
MINERALS
Ash (%DM)
Calcium (%DM)
Phosphorus (%DM)
Magnesium (%DM)
Potassium (%DM)
Sulfur (%DM)
Sodium (%DM)
Chloride (%DM)
Iron (PPM)
Manganese (PPM)
Zinc (PPM)
Copper (PPM)
Molybdenum (PPM)
DCAD (meq/100gdm)
FERMENTATION
ENERGY & INDEX CALCULATIONS
Non Structural Carbohydrates
TDN (%DM)
Net Energy Lactation (mcal/lb)
Net Energy Maintenance (mcal/lb)
Net Energy Gain (mcal/lb)
Non Fiber Carbohydrates (%DM)
Non Structural Carbohydrates (%DM)

Feed Codes:	ALMOND HULLS
# of Samples:	415
Date Range:	1/1/2019 To 11/27/2019
Region:	West

ANALYSIS RESULTS	AVERAGE	# OF SAMPLES	ST DEV	COV	-1 SD	+1 SD
Dry Matter (%DM)	91.1	415	3.86	4.2	87.2	94.9
Moisture (%DM)	8.93	415	3.86	43.2	5.07	12.8
PROTEINS	**AVERAGE**	**# OF SAMPLES**	**ST DEV**	**COV**	**-1 SD**	**+1 SD**
Crude Protein (%DM)	5.83	391	1.18	20.2	4.65	7.01
Adjusted Protein (%DM)	5.44	108	1.27	23.3	4.17	6.71
Soluble Protein (%CP)	37.1	107	9.68	26.1	27.4	46.8
ADF Protein (ADICP) (%DM)	0.89	39	0.52	58.4	0.37	1.41
NDF Protein (NDICP) (%DM)	1.17	37	0.62	53	0.55	1.79
FIBER	**AVERAGE**	**# OF SAMPLES**	**ST DEV**	**COV**	**-1 SD**	**+1 SD**
Acid Detergent Fiber (%DM)	23.2	396	7.84	33.7	15.4	31.1
Neutral Detergent Fiber (%DM)	29.4	394	9.4	31.9	20	38.8
Crude Fiber (%DM)	22.4	102	11.5	51.3	10.9	33.8
Lignin (%DM)	11.8	74	5.71	48.5	6.07	17.5
Lignin / NDF Ratio	36.1	74	7.18	19.9	29	43.3
NDF 30 HR Digestibility (%NDF)	31.6	7	6.86	21.7	24.7	38.4
CARBOHYDRATES	**AVERAGE**	**# OF SAMPLES**	**ST DEV**	**COV**	**-1 SD**	**+1 SD**
Ethanol Soluble CHO (Sugar) (%DM)	30.1	364	8.39	27.9	21.7	38.5
Starch (%DM)	0.52	71	0.44	84.6	0.08	0.96
Crude Fat (%DM)	2.53	402	1.4	55.3	1.13	3.93
MINERALS	**AVERAGE**	**# OF SAMPLES**	**ST DEV**	**COV**	**-1 SD**	**+1 SD**
Ash (%DM)	7.27	389	1.1	15.1	6.17	8.37
Calcium (%DM)	0.26	111	0.1	38.5	0.16	0.36
Phosphorus (%DM)	0.12	111	0.03	25	0.09	0.15
Magnesium (%DM)	0.11	111	0.02	18.2	0.09	0.13
Potassium (%DM)	2.69	111	0.68	25.3	2.01	3.37
Sulfur (%DM)	0.05	29	0.01	20	0.04	0.06
Sodium (%DM)	0.02	111	0.01	50	0.01	0.03
Chloride (%DM)	0.07	28	0.03	42.9	0.04	0.1
Iron (PPM)	244	111	175	71.7	69.1	419
Manganese (PPM)	16.2	111	5.39	33.3	10.8	21.6
Zinc (PPM)	17.1	111	13.8	80.7	3.31	31
Copper (PPM)	6.46	111	4.01	62.1	2.45	10.5
DCAD (meq/100gdm)	69.4	28	10.7	15.3	58.8	80.1
FERMENTATION	**AVERAGE**	**# OF SAMPLES**	**ST DEV**	**COV**	**-1 SD**	**+1 SD**
ENERGY & INDEX CALCULATIONS	**AVERAGE**	**# OF SAMPLES**	**ST DEV**	**COV**	**-1 SD**	**+1 SD**
Non Structural Carbohydrates	25.3	69	10.3	40.7	15	35.6
TDN (%DM)	70.2	396	6.69	9.5	63.5	76.9
Net Energy Lactation (mcal/lb)	0.73	396	0.07	9.6	0.66	0.8
Net Energy Maintenance (mcal/lb)	0.74	396	0.1	13.5	0.64	0.84
Net Energy Gain (mcal/lb)	0.47	396	0.09	19.1	0.38	0.56
Non Fiber Carbohydrates (%DM)	53.7	107	14.4	26.9	39.3	68.2
Non Structural Carbohydrates (%DM)	26.5	415	12.6	47.7	13.9	39.1

The samples reported are from on farm samples, used for formulation and quality analysis by dairymen, nutritionist and buyers

What varies year to year?

	2017			2018			2019		
Nutrient	Average	-1 STDEV	+1 STDEV	Average	-1 STDEV	+1 STDEV	Average	-1 STDEV	+1 STDEV
Crude Protein	**6.16**	*4.48*	*7.84*	**6.3**	*4.8*	*7.8*	**5.83**	*4.63*	*7.01*
ADF	**23**	*17.5*	*28.6*	**23.2**	*17.7*	*28.8*	**23.2**	*15.4*	*31.1*
NDF	**31.6**	*25.4*	*37.8*	**29.5**	*22.7*	*36.3*	**29.4**	*20*	*38.8*
Sugar	**31.6**	*25.4*	*37.8*	**31.6**	*24.7*	*38.5*	**30.1**	*21.7*	*38.5*
Fat	**2.37**	*0.59*	*4.15*	**2.56**	*0.12*	*5*	**2.53**	*1.13*	*3.93*
ASH	**7.45**	*6.46*	*8.44*	**7.41**	*6.5*	*8.32*	**7.27**	*6.17*	*8.37*
NeL	**0.73**	*0.67*	*0.79*	**0.74**	*0.67*	*0.81*	**0.73**	*0.66*	*0.80*
NDFD30	**28.6**	*25.5*	*31.7*	**15.4**	*14.7*	*16.1*	**31.6**	*24.7*	*38.4*

Sugar??? Really?

- Chemically, what makes up Almond hulls
  - The carbohydrates get mixed between fiber and sugar on the standard feed test
- We have been told for years that they contain pectin…. But where is it?
- Work by ABC has shown that actual pectin content runs between 2-3 % of mass.
- We also know that green hulls contain larger amounts of starch then sugar.

Let's review how the forage digestibility compares

	Corn Silage	BMR	Almond Hulls	Pure Hulls	Non Hulls
Sample #	532	21	177	1	1
Dry Matter	34.5	34.6	86.1	91.3	91.7
Protein	7.96	7.94	5.81	4	4.7
NDF	41.6	44.7	28.3	21.7	58.2
NDFD30	59.1	69.7	29.5	-	-
ADF	26.1	27.7	20.7	15.5	41.9
Lignin	2.96	2.37	12.3	11.4	19.95
Starch	28.6	24.6	2.03	0.4	0.4
Sugar	2.43	2.97	32.03	38.1	12.3

What is NDFD 30 and why do cows care

- The ability for dairy cattle to make milk is directly related to the amount they can eat.
  - If we can increase the amount of intake milk production is increased at a rate of 1:1.5

- NDFD 30 is the amount of NDF that digests in 30 hours and is an indication of quality for all forage type products.

- In general, the larger the NDFD30 value the more valuable the feed stuff as a source to produce milk.

Compared to standard / accepted feed stuffs, Almond Hulls look like a poor source of digestible forage!

What Happened to the Mass?

- The **law of conservation of mass** states that mass can not be created nor destroyed.

- On a standard feed sample, the mass reported should total 100%.
  - Due to separate analytical methods for each portion of a feed, the total should “actually” be very near 100%

- The quick method for determining if the sample nears 100% is
  - Protein + NDF+Fat+Sugar+Starch+Ash

This Sample again….

SAMPLE INFORMATION			
Lab ID:	27272 095	Series:	
Crop Year:	2019	Version:	1.0
Cutting #:			
Feed Type:	ALMOND HULLS		

CHEMISTRY ANALYSIS RESULTS	
Moisture	9.4
Dry Matter	90.6

PROTEINS	% SP	% CP	% DM
Crude Protein			4.0
Adjusted Protein			
Soluble Protein		28.3	1.1
Ammonia (CPE)			
ADF Protein (ADICP)		19.3	0.77
NDF Protein (NDICP)		25.2	1.00
NDR Protein (NDRCP)			
Rumen Degr. Protein			

FIBER	% NDF	% DM
ADF	66.7	
aNDF		30.7
aNDFom		
NDR (NDF w/o sulfite)		
Crude Fiber		
Lignin	33.71	10.36
NDF Digestibility (12 hr)		
NDF Digestibility (24 hr)		
NDF Digestibility (30 hr)		
NDF Digestibility (72 hr)		
NDF Digestibility (240 hr)		
uNDF (30 hr)		
uNDF (240 hr)		

CARBOHYDRATES	% Starch	% NFC	% DM
Silage Acids			
Ethanol Soluble CHO (ESC-Sugar)		51.3	30.1
Water Soluble CHO (WSC-Sugar)			
Starch		0.7	0.4
Soluble Starch			
Soluble Fiber			
Starch Digestibility (7 hr)			
Crude Fat			1.79
Fatty Acids, Total (%DM)			
Acid Hydrolysis Fat			

MINERALS	
Ash (%DM)	5.80
Calcium (%DM)	
Phosphorus (%DM)	0.09
Magnesium (%DM)	0.11
Potassium (%DM)	2.57
Sulfur (%DM)	0.04
Sodium (%DM)	0.02
Chloride (%DM)	0.04
Iron (PPM)	77
Manganese (PPM)	11
Zinc (PPM)	7
Copper (PPM)	5
Molybdenum (PPM)	

FERMENTATION	
Total VFA	
Lactic Acid (%DM)	
Lactic as % of Total VFA	
Acetic Acid (%DM)	
Propionic Acid (%DM)	
Butyric Acid (%DM)	
Isobutyric Acid (%DM)	
1, 2 Propanediol (%DM)	
Nitrate Ion (%DM)	

ENERGY & INDEX CALCULATIONS	
pH	
TDN (%DM)	63.6
Net Energy Lactation (Mcal/lb)	0.64
Net Energy Maintenance (Mcal/lb)	0.63
Net Energy Gain (Mcal/lb)	0.36
ME (Mcal/lb)	1.1
NDF Dig. Rate (Kd, %HR, Van Amburgh, Lignin*2.4)	
NDF Dig. Rate (Kd, %HR, Van Amburgh, iNDF)	
Relative Feed Value (RFV)	
Relative Forage Quality (RFQ)	
Milk per Ton (lbs/ton)	
Dig. Organic Matter Index (lbs/ton)	
Non Fiber Carbohydrates (%DM)	58.71
Non Structural Carbohydrates (%DM)	30.5
DCAD (meq/100gdm)	63.2

Additional sample information, submitted documents and lab pictures linked to QR code

Total mass reported:

72.79%

What's missing?

What does this mean?

- Currently Almond hulls look worse on paper then they feed.
- Survey results (Heguy et.al) indicate that nutritionist use Almond Hulls as a source of digestible fiber, comparable to Almond Hulls.

- However, the lack of a complete nutritional profile limit the ability for ration balancing software to completely value Almond Hulls.

- This leaves a fundamental gap in the understanding of what and how almond hulls work in the digestive system of dairy cattle.

Where to????

- Determine what comprises the missing mass?
  - What methods can we use?
  - How do those methods overlap / compare to understood analytical methods?

- Develop nutrition model inputs that represent the “complete” mass of almond hulls, allowing for complete analysis of their value as a feed stuff.

- The missing mass is being digested… according to our un-biased customer… What is it?

Thank You.

More Almond Hulls for California Dairy Cows?

california almonds®
Almond Board of California

Thank you!