California Animal Nutrition Conference 2022

Almond Hulls For Lactating Dairy Cows: Feeding Amounts & Composition

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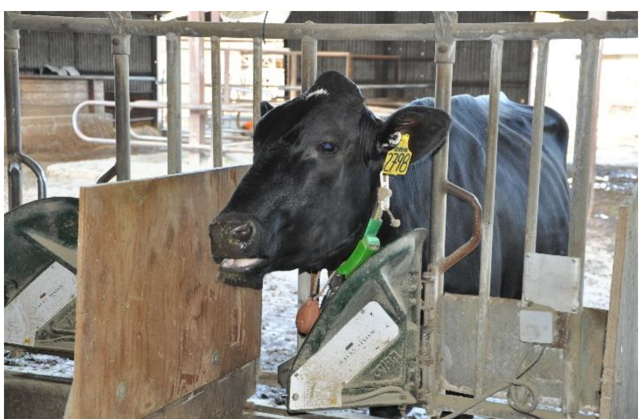


Team Effort

- 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)
  - Maia Zack (technician)
  - Hernan Rodriguez (technician)
  - **Katie Swanson** (postdoctoral)
  - Staff at Dairy Facility & Feed Mill
  - Student Interns

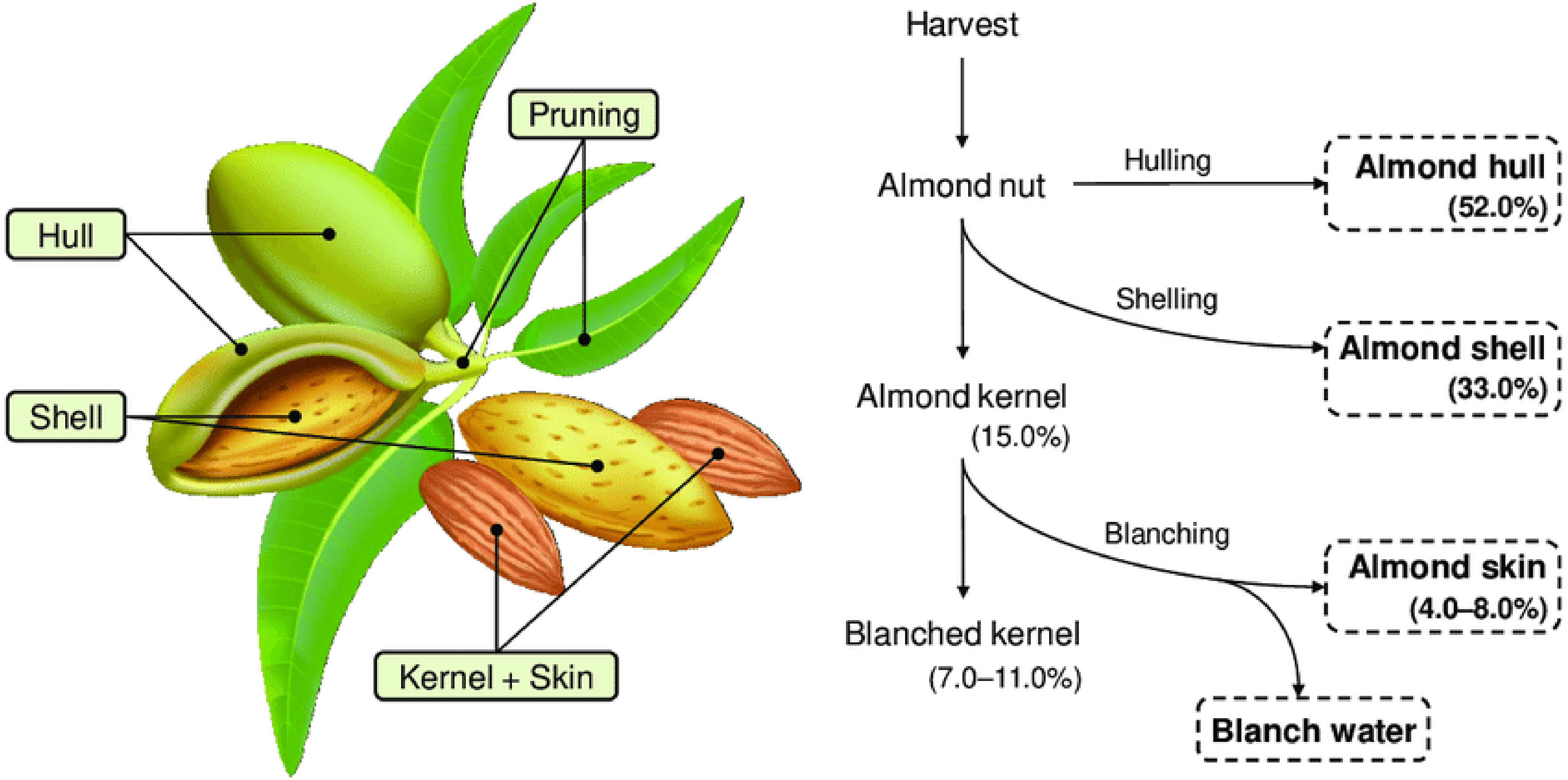
Approach Today

1. Nutrient Composition of Almond Hulls
2. Survey of CA Nutritionists on Almond Hull Usage
3. *In Vitro* Assessment of Almond Hulls
4. Feeding Value of Almonds Hulls
5. Variation in Composition and Regulatory Issues
6. Current and Future Research
7. Summary

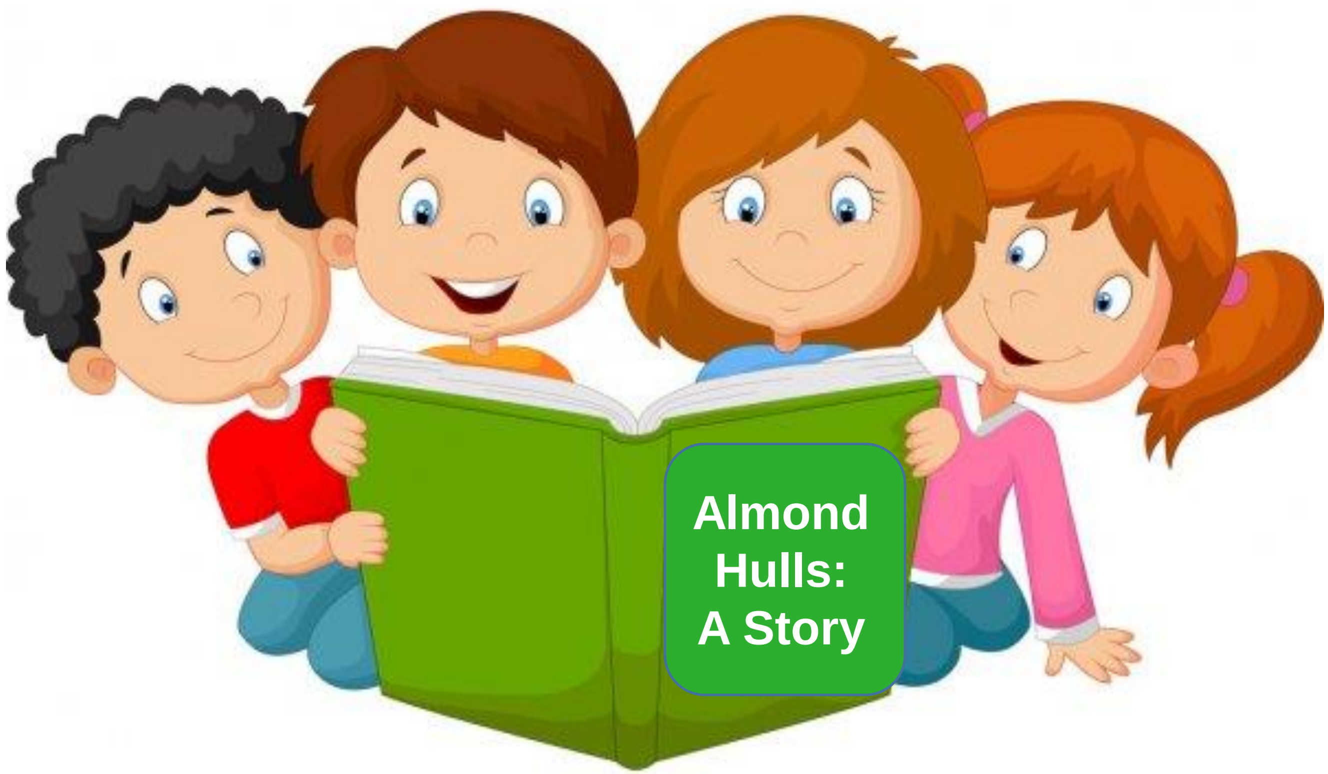
Story

Brief History of Almond Hulls

Almond hulls are a byproduct from the production of almond nuts. Archaeological evidence - almonds were cultivated about 3,000 B.C. Selection for almond nuts may have been much earlier. Wild almond species have toxic cyanogenic glycoside amygdalin. Domestication of almonds selected against amygalin to create edible nuts.



Almond Hulls as a Byproduct Feedstuff



Almond hulls are defined in CA by commercial feed laws:
"They shall not contain more than 13.0 percent moisture, **nor more than 15.0 percent crude fiber**, and not more than 9.0 percent ash."

What is the basis for the chemical composition requirements?

CDFA Commercial Feed Law and Regulations

Almond hulls are defined in CA by commercial feed law 2773.5: "They shall not contain more than 13.0 percent moisture, **nor more than 15.0 percent crude fiber**, and not more than 9.0 percent ash."

History of Almond Hulls (AH)

- **<u>1940s</u>**
  - AH were <u>not</u> used as livestock feed in CA.
  - Either burned or plowed under.
- **<u>1951</u>** UC Davis demonstrated the nutritive value of AH for ruminants.
- **<u>1984</u>** UC Davis established the feeding value of AH for lactating dairy cows.
- **<u>2020</u>** Common feedstuff. Commodity that is typically reported as undervalued; economical & nutritious byproduct feedstuff for dairy cattle.

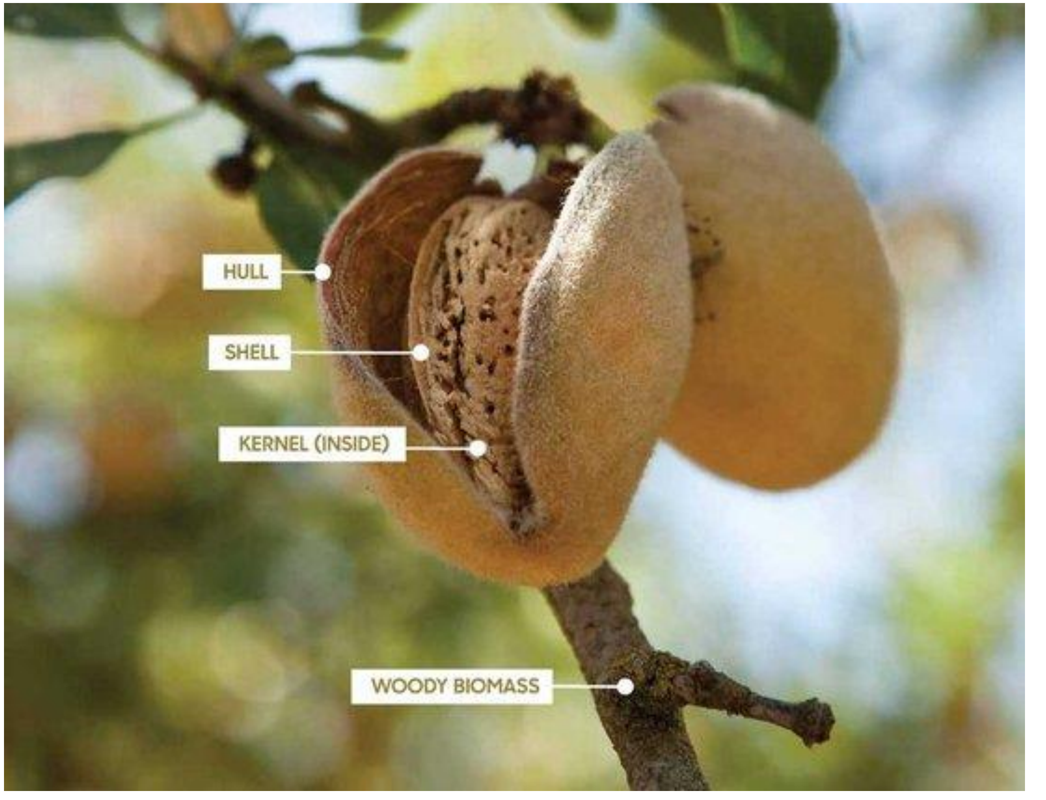
CA Almond Production

- Crop Year 2019/2020:
  - 1.83 bil kg hulls (49%)
  - 0.75 bil kg shells (20%)
  - 1.16 bil kg nuts (31%)
- CA is the world leader in the production of almond nuts 2019
- In 2019 there were 1.18 million acres of bearing orchards and 350,000 of non bearing orchards.
- Almond nut production increased 63% in 2019/20 compared with 2007.
- In 2019 farm value of almonds was $6.1 billion, #2 farm commodity value in Ca, behind milk ($7.3 billion). **How long before #1?**

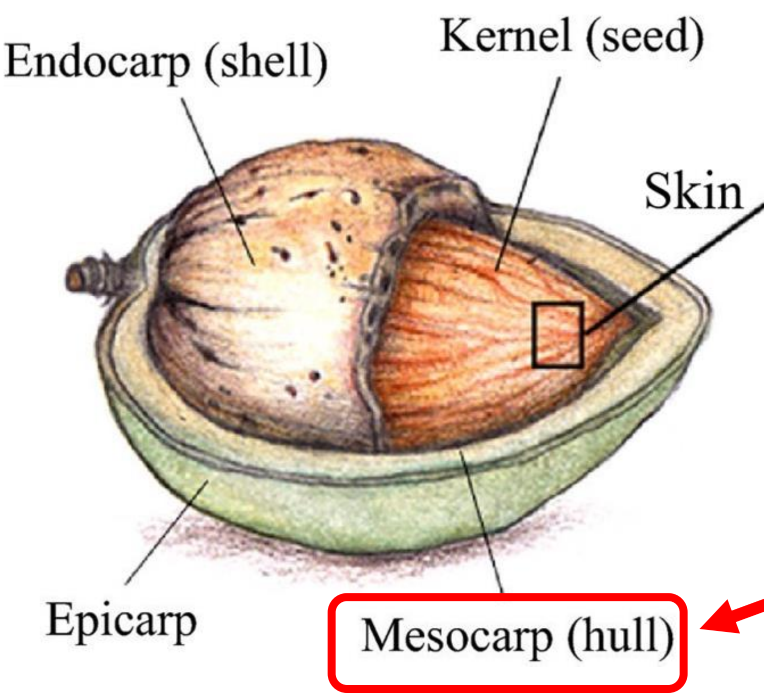
(2020 Almond Almanac)

Almond Hulls (AH)

Almond Hulls are a byproduct feedstuff for ruminants that are created in the production of nuts for human consumption.



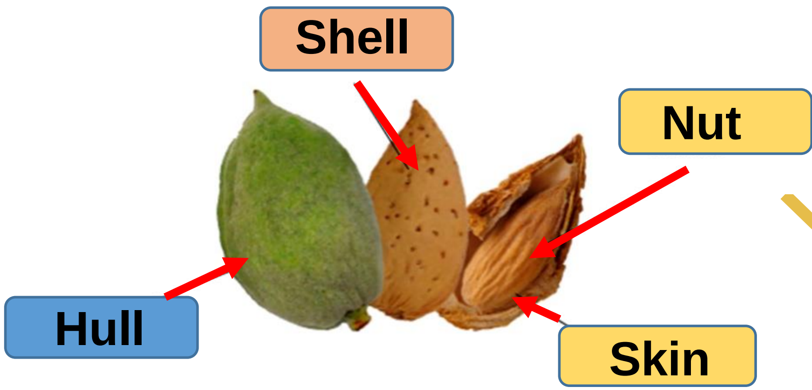
- Almonds belong to the family of stone fruits including peaches & cherries.
- Hull is **anatomically similar** to the fleshy portion of the peach that we eat.



Almond Hulls are high in sugars

Field Weight Yields

In 2019/20, there were 2.2 billion pounds of nuts and **4.4 billion pounds of hulls** produced.



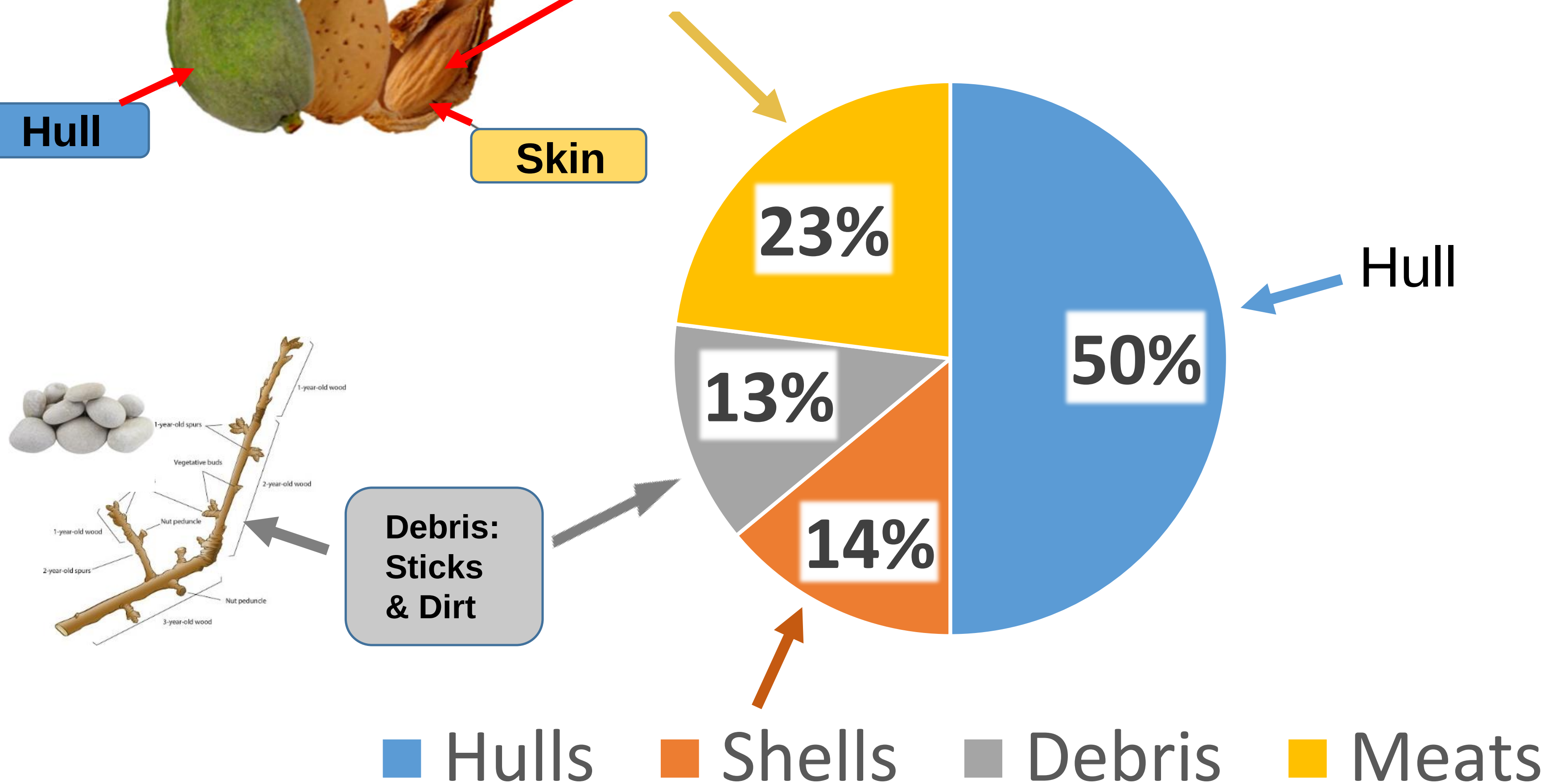
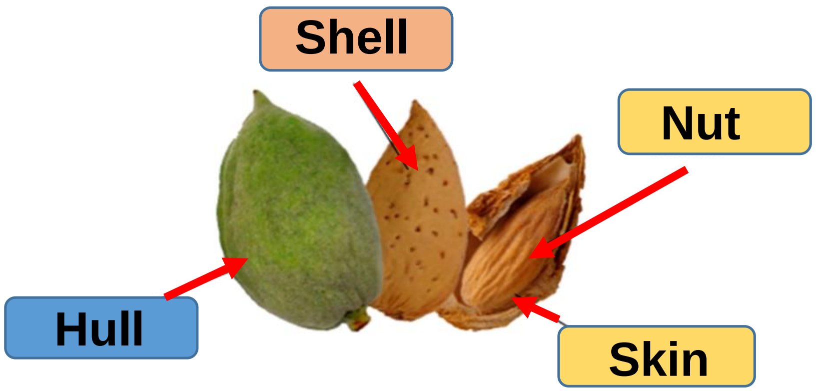
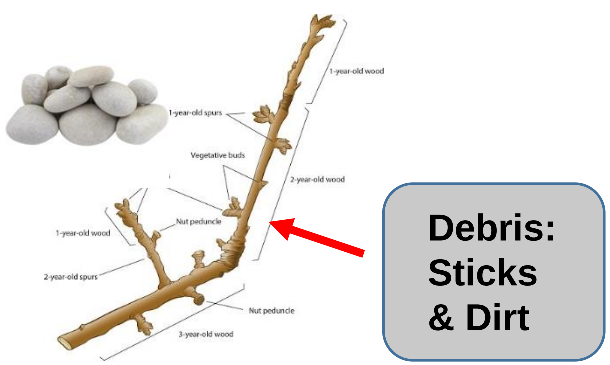


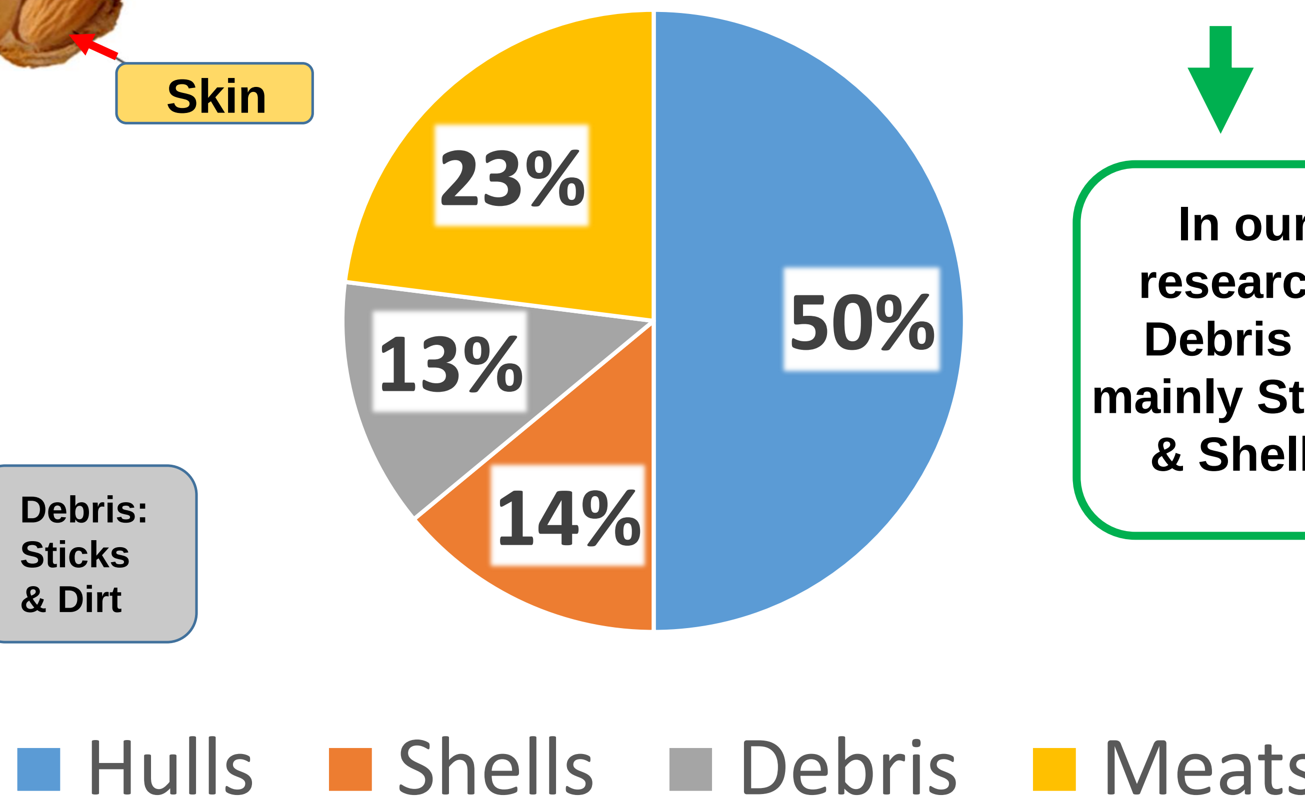
Figure is from Environmental Protection Agency. Food & Agricultural Industry 2017

Field Weight Yields

In 2019/20, there were 2.2 billion pounds of nuts and **4.4 billion pounds of hulls** produced.





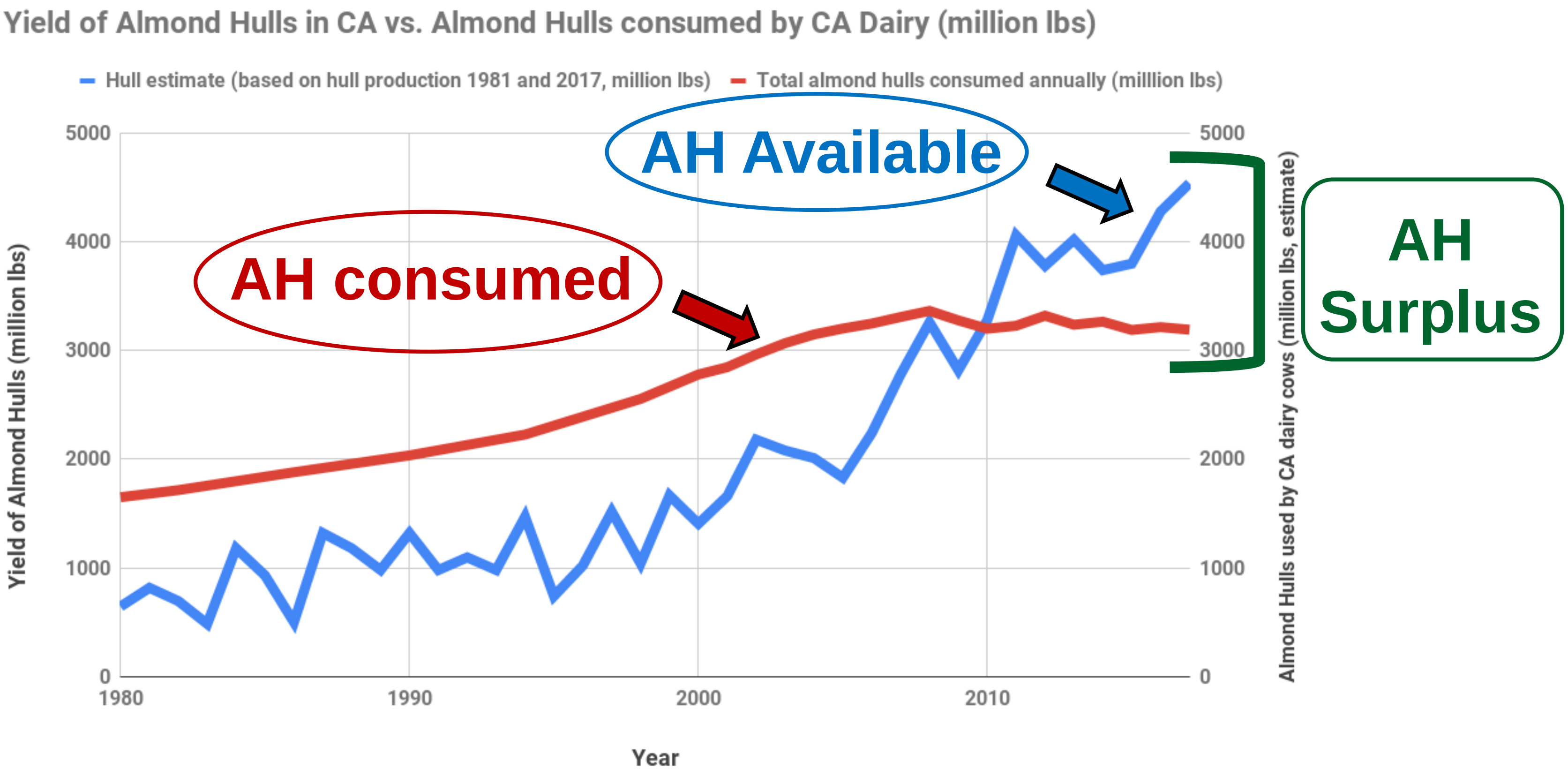


In our research, Debris is mainly Sticks & Shells

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

Projected AH Quantity & Dairy Cow Consumption

At 5 lb AH/cow daily there will be a surplus of AH.

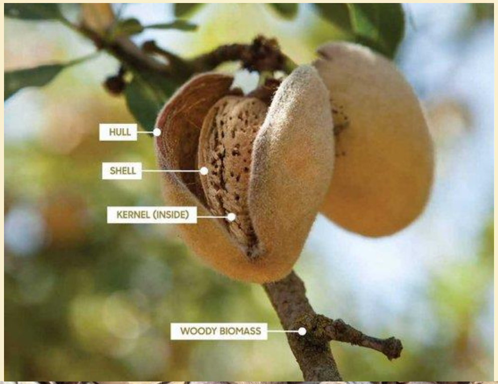


Milk cows in CA are fed ~5 lb As Fed almond hulls (Heguy 2020)

Question our research addressed: Can high amounts of almond hulls be fed to high producing dairy cows?

Composition of Almond Hulls

Almond Hulls are a "Commodity"



What is the Nutrient Composition of the Almond Hulls?

1. **Fiber (%NDF,** %ADF, **%CF)**
2. **Ash**
3. **Lignin**
4. **Sugar**
5. **Mold**
6. **Energy**

CUMBERLAND VALLEY ANALYTICAL SERVICES

" Laboratory services for agriculture ... from the field to the feed bunk "

CVAS

Type:	**ALMOND HULLS**	**Copies to:**	**HOLMES, LISA**	Lab ID:	**26762 021**
Farm:	**UCD ALMOND HULL 4**		**BILL, HANNAH**	Sampled:	
Desc:	**ALMOND HULLS ED**		**SWANSON, KATIE**	Arrived:	**08/15/2019**
	DEPETERS ED			Completed:	**08/23/2019**
	NUT 115	**Regression:**	**OH**	Reported:	**08/23/2019**

ALMOND HULLS ED

SAMPLE INFORMATION			
Lab ID:	26762 021	Series:	
Crop Year:	2019	Version:	1.0
Cutting#:			
Feed Type:	ALMOND HULLS		

CHEMISTRY ANALYSIS RESULTS	
Moisture	11.7
Dry Matter	88.3

PROTEINS	% SP	% CP	% DM
Crude Protein			4.6
Adjusted Protein			4.6
Soluble Protein		32.3	1.5
Ammonia (CPE)			
ADF Protein (ADICP)			
NDF Protein (NDICP)			
NDR Protein (NDRCP)			
Rumen Degr. Protein			

FIBER	% NDF	% DM
ADF	67.8	16.1
aNDF		24.1
aNDFom		23.7
NDR (NDF w/o sulfite)		
Crude Fiber	59.9	14.2
Lignin	31.49	7.48
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)		47.0	29.7
Water Soluble CHO (WSC-Sugar)			
Starch			
Soluble Starch			
Soluble Fiber			
Starch Digestibility (7 hr)			
Crude Fat			
Fatty Acids, Total (%DM)			
Acid Hydrolysis Fat			

MINERALS	
Ash (%DM)	6.06
Calcium (%DM)	0.20
Phosphorus (%DM)	0.11
Magnesium (%DM)	0.10
Potassium (%DM)	2.43
Sulfur (%DM)	
Sodium (%DM)	0.03
Chloride (%DM)	
Iron (PPM)	161
Manganese (PPM)	15
Zinc (PPM)	16
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)	70.1
Net Energy Lactation (Mcal/lb)	0.70
Net Energy Maintenance (Mcal/lb)	0.71
Net Energy Gain (Mcal/lb)	0.44
ME (Mcal/lb)	2.7
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)	63.23
Non Structural Carbohydrates (%DM)	29.7
DCAD (meq/100gdm)	

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

Variation in Composition: Aguilar et al. (1984)

Item DM	Merced	Nonpareil	Neplus
CF, %	**14.4**	**14.3**	**21.1**
range	14-15	12-17	17-25
ADF, %	**21.5**	**27.3**	**29.9**
range	21-23	20-35	25-35
Sugars, %	**26.4**	**31.7**	**23.9**
range	20-33	21-34	19-29
CP, %	**5.4**	**6.7**	**6.1**
range	5-6	5-9	5-7
Lignin, %	**7.9**	**12.1**	**11.7**
range	7-8	8-17	8-16

Composition Study

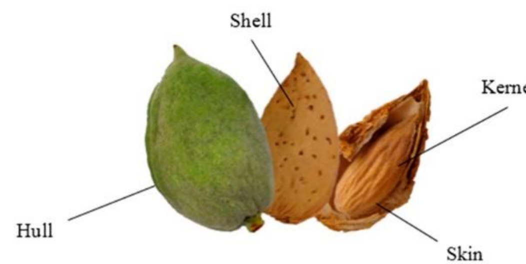
To determine the impact of Debris (Sticks & Shells) on chemical composition of almond hulls:

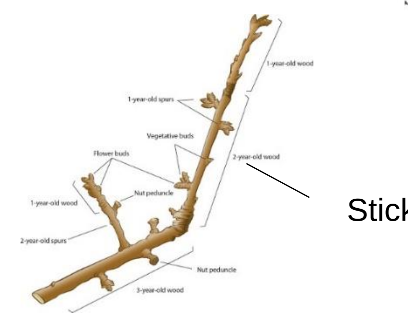
- 12 samples of commercial AH (**“Total” Hulls**) were obtained from hullers.
- 5 Nonpareil AH & 7 Other Variety AH (Pollinators).
- Hand sorted each sample to separate into **“Pure” Hulls** and **Debris** (Sticks & Shells).

- **Total Hulls, Pure Hulls, and Debris** were analyzed for chemical composition.

Sticks
Shells

Pure Hulls





Proportion of Debris in Commercial AH (wt/wt)

5 Nonpareil: **4.7% Debris (Sticks/Shells)**
7 Other Variety : **6.8% Debris (Sticks/Shells)**

Variation in Composition – hull component

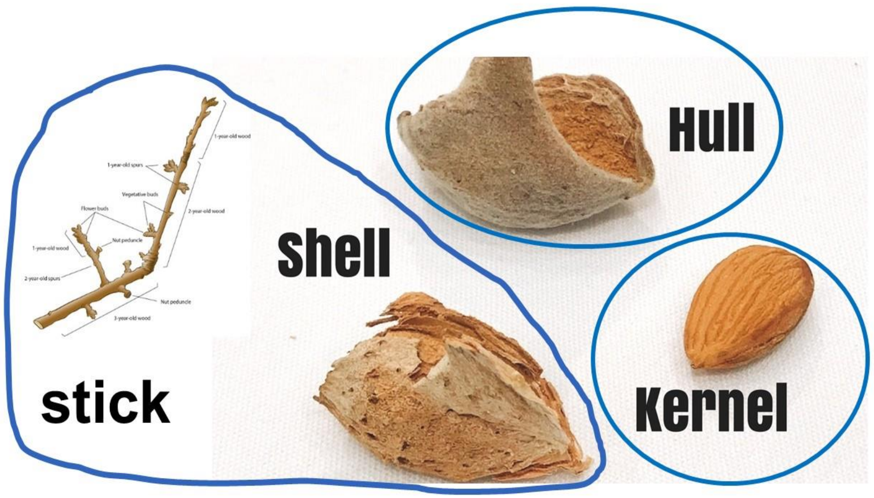
- Variation was measured in commercial almond hulls that the composition reflects hulls and debris (sticks & shells).
- Nonpareil had 4.7% debris while Other Variety had 6.8% debris.

% Debris

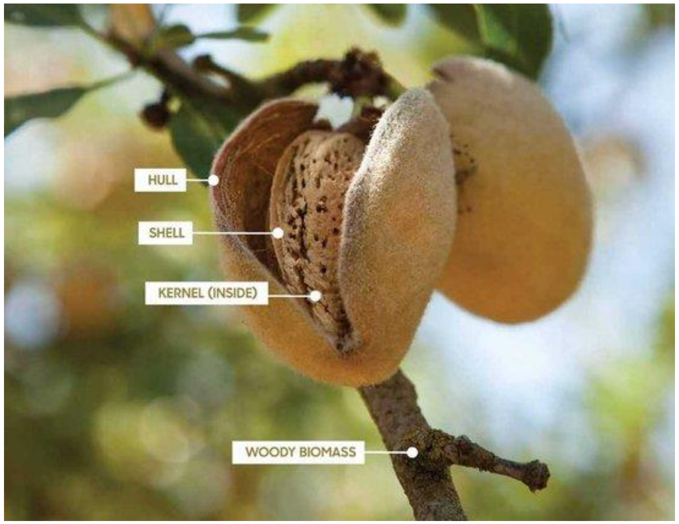
Variety	DePeters	Offeman
Nonpareil	4.7%	4.5%
Monterey	5.1%	7.4%
Butte/Padre	9.1%	14.7% Butte
		13.0% Padre

"Stick tights"

Almond Huller

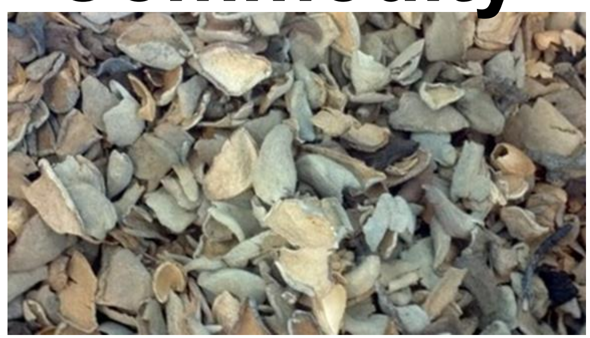


Commercial Almond Hulls – Composition



Variety

‘Commodity’



Harvesting

Agronomic

↓ Debris ↑ Quality

Composition of Almond Hulls: Nonpareil

Item DM basis	Total AH	Pure AH (No stick & shell)	Debris (stick & shell)
CF, %	14.6	13.0	44.4
CP, %	5.1	5.1	6.9
EtOH CHO, %	32.6	33.6	7.9
aNDF, %	21.4	19.3	62.3
NSC, %	32.9	34.0	8.3
NEL, Mcal/lb	0.71	0.74	0.47

Sticks & Shells decreased the sugar and energy content.
Sticks & Shells increased the fiber content.

Variation in Composition: Nonpareil Variety

Item	TAH	PAH	Debris
CF, %	**14.6**	**13.0**	**44.4**
range	13.2-15.4	12.1-14.6	39.1-52.2
NDFom, %	**21.0**	**18.8**	**60.7**
range	18.2-22.4	17.5-20.6	54.2-71.0
Sugars, %	**32.6**	**33.6**	**7.9**
range	27.3-36.4	28.0-39.9	4.8-13.4
CP, %	**5.1**	**5.1**	**6.9**
range	3.8-6.4	3.8-6.7	4.5-9.0
Lignin, %	**8.6**	**7.6**	**22.4**
range	7.6-9.4	7.0-8.8	19.4-25.8

Variation in Composition: Other Variety

Item	TAH	PAH	Debris
CF, %	**18.1**	**15.1**	**49.4**
range	15.9-19.7	13.3-17.2	39.8-54.8
NDFom, %	**24.9**	**21.5**	**68.3**
range	20.0-31.3	19.5-22.9	59.1-77.1
Sugars, %	**28.0**	**29.5**	**5.4**
range	21.4-31.2	23.3-35.0	3.7-9.6
CP, %	**5.0**	**4.9**	**5.4**
range	4.0-8.0	3.8-8.0	3.3-9.6
Lignin, %	**9.7**	**8.7**	**22.7**
range	6.9-12.5	7.3-12.8	17.9-26.2

Composition of Total Almond Hulls (Variety)

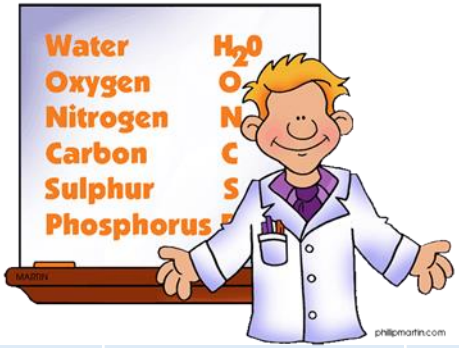
Item	Nonpareil AVG	Other AVG
CF, %	14.6	18.1
CF, % As Is	12.7	15.9*
Lignin, %	8.6	9.7
CP, %	5.1	5.0
EtOH CHO, %	32.6	28.0
aNDF, %	21.4	25.5

Other = Pollinators

Nonpareil > Other

CA law: Almond hulls < 15% crude fiber on an As Is basis.

General Composition



Item	Average	SD	Range
DM, %	92.9	1.3	89.4-95.1
CF, %	12.9	2.1	10.4-19.1
NDF, %	20.9	3.7	17.1-31.2
ADF seg, %	13.6	2.8	8.1-21.3
ADL, %	3.3	0.9	2.1-5.2
Ash, %	7.4	1.0	5.6-9.7
Fat, %	1.5	0.6	0.3-3.6

N= 32; 19 Nonpareil, 8 California, & 5 Hardshell.
Almond Board of California.

Non-fiber Carbohydrates

	Average	SD	Range
Total Sugars, %	28.0	6.3	16.1-37.4
Glucose, %	14.5	4.0	7.2-20.1
Fructose, %	7.5	1.1	4.6-8.9
Sucrose, %	5.4	1.6	2.7-9.4
Starch, %	0.3	0.3	0.02-1.0

N= 32; 19 Nonpareil, 8 California, & 5 Hardshell.
Almond Board of California.

Minerals

	Average	SD	Range
K, %	2.5	0.4	2.0-3.2
Ca, %	0.2	0.0	0.1-0.3
Mg, %	0.1	0.0	0.07-0.1
P, %	0.1	0.0	0.04-0.2
Cl, %	0.1	0.0	<0.1-0.2
Na, %	0.0	0.0	<0.1
S, %	0.0	0.0	0.02-0.04

N= 32; 19 Nonpareil, 8 California, & 5 Hardshell.
Almond Board of California.

Lab Comparison (Variation)

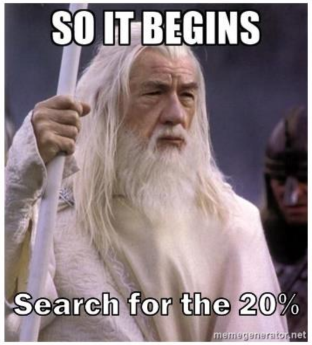
	Nonpareil	Nonpareil	Monterey	Monterey
Moisture, %	8.8	13.6	8.0	7.8
NDF, %	18.1	24.0	16.6	22.4
Lignin, %	9.3	3.6	7.3	2.8
Ash, %	6.4	8.1	7.2	8.1
CP, %	2.5	2.9	3.8	3.9
Sugar, %	28.2	21.5	20.0	19.6

Lab 1 versus Lab 2

Missing 20%

Item	Almond Hulls	Alfalfa Hay
NDF, %	27	39
CP, %	4	21
Sugars, %	31	6
Ash, %	6	11
Fat	2	2
Starch, %	0.5	1.5
Total, %	**70.5**	**80.5**

Klason Lignin



Item	Nonpareil	Mission	Monterey
Lignin, %	**24.4**	**24.5**	**26.3**
Cellulose, %	16.0	18.9	18.3
Hemicellulose, %	17.8	17.5	18.3
Fiber, %	58.1	61.0	62.9
Extractives, %	44.8	42.2	37.0
Ash, %	9.4	5.2	5.2

Advanced Biofuels and Bioproducts; Berkeley Lab 2017/2018.

Klason Lignin – Acid Detergent Lignin = “Soluble” Lignin

Composition of Almond Hulls

<u>Take Home Messages</u>

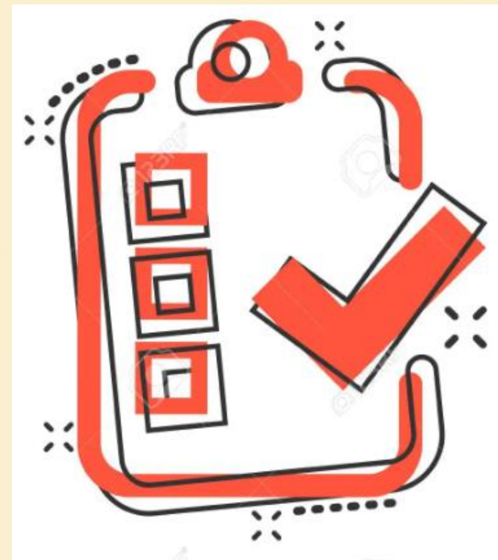
Almond hulls are an excellent source of NSC – sugars.

Nonpareil hulls are superior to other hulls. Blend hulls.

Hull composition is variable (commodity, sampling & lab).

As a commodity, reducing the Debris (Sticks & Shells) in almond hulls improves nutritional value.

Survey of CA Nutritionists



Survey of CA Nutritionists (2019)

<u>Average & Maximum Feeding Rates for Lactating Cows</u>

	Average	Range
Average feeding rate	2.3 kg	0.5 – 4.5 kg
Maximum feeding rate	4.6 kg	0.9 – 8.2 kg

In the previous 5-year period (2014-18) almond hull usage increased (41%), remained unchanged (44%), or decreased (15%).

Survey of CA Nutritionists (2019)

Almond Hull Utilization in Dairy Rations

Ration	Forage	Concentrate	Forage & Concentrate
Lactating Cow	30%	0%	70%
Dry Cow	31%	7%	62%
Heifer Growing	29%	9%	62%

Almond hulls were used as both a forage and a concentrate ingredient – reflecting the **versatility** of hulls in feeding dairy cattle.

Survey of CA Nutritionists (2019)

Responsiveness of inclusion - considerations

	Very	Somewhat	Not
Price (n=38)	32	6	0
Consistency (n=38)	30	7	1
Mold (n=35)	29	5	1
Quality (n=37)	27	9	1
CF (n=36)	15	16	5
ADF (n=35)	15	16	4
Ash (n=34)	14	16	4
Sugar (n=36)	13	19	3
NDF (n=36)	11	21	3

Survey of CA Nutritionists (2019)

Take Home Messages

Almond hull feeding will likely increase in response of increased availability with rising orchard acreage.

Water availability will likely place more importance to feeding almond hulls – as a forage ingredient to replace silage.

Opportunity to increase the feeding rates in dairy cattle diets is increasing.

In Vitro Assessment of Almond Hulls

In Sacco: NDF Degradation (DePeters et al. 1997)

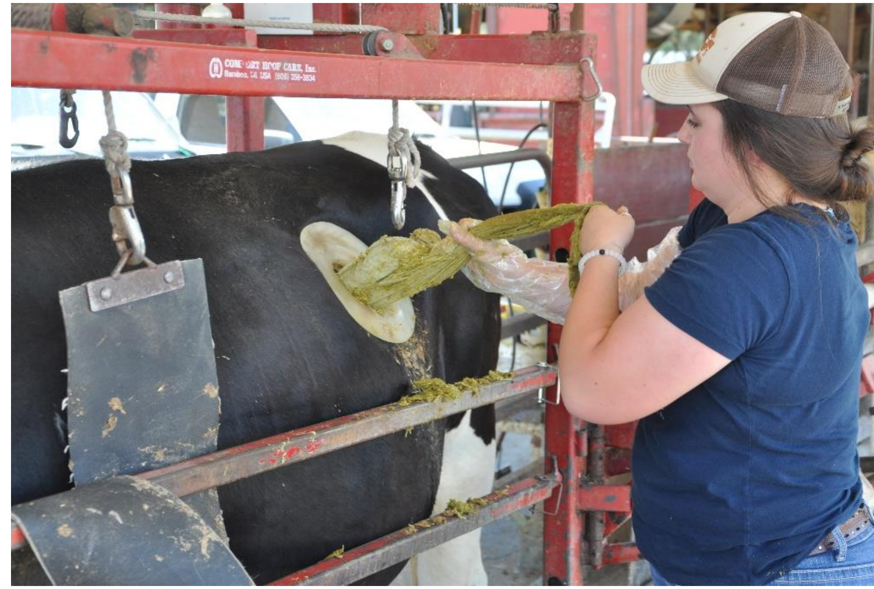
	Degradable Fraction (%)	K_d (h^{-1})
Almond hull 1	19.9	0.051
Almond hull 2	16.3	0.040
Almond hull 3	13.2	0.039
Average	**16.5**	**0.043**
Soy hull 1	59.5	0.036
Soy hull 2	62.5	0.038
Soy hull3	56.6	0.039
Average	**59.7**	**0.038**

In Sacco Disappearance

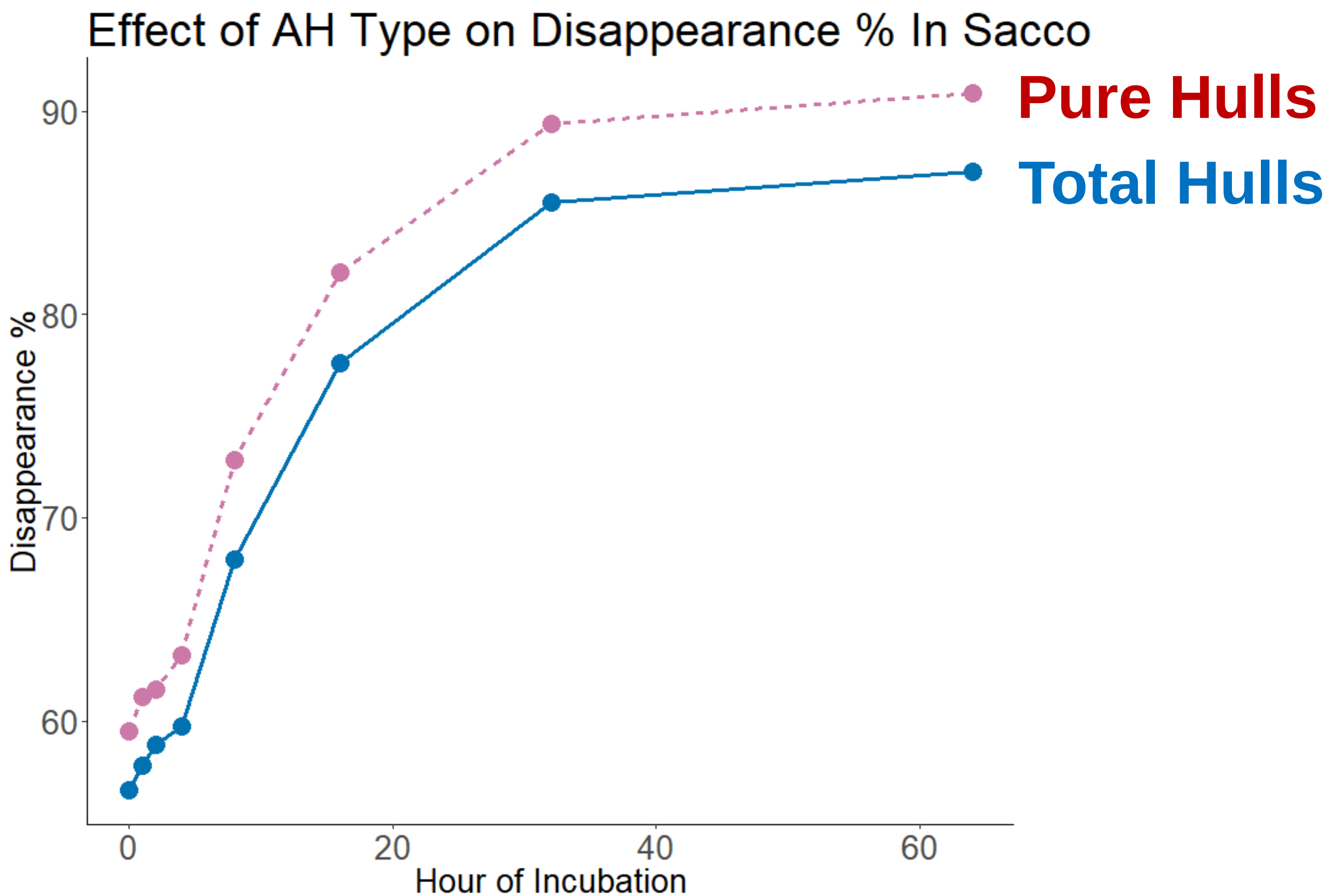
- 2 nonlactating, open, rumen-cannulated Holstein cows
- Monofilament “nylon” bags
- Replicated runs
- Incubation time points:

0, 1, 2, 4, 8, 16, 32, & 64 hr

- Non-linear mixed model
- Total Almond Hulls (TAH) and Pure Almond Hulls (PAH)

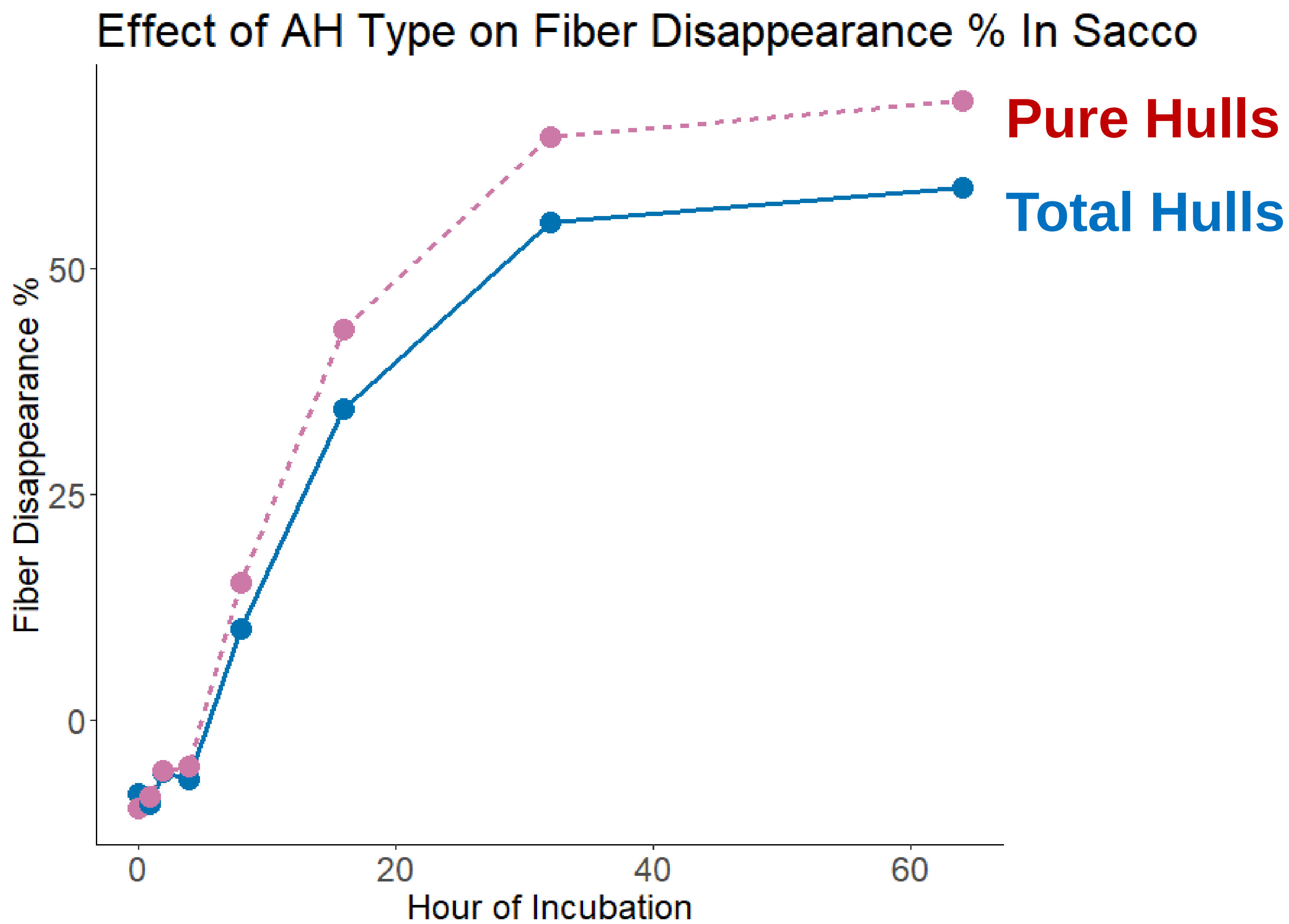


In Sacco Dry Matter Disappearance

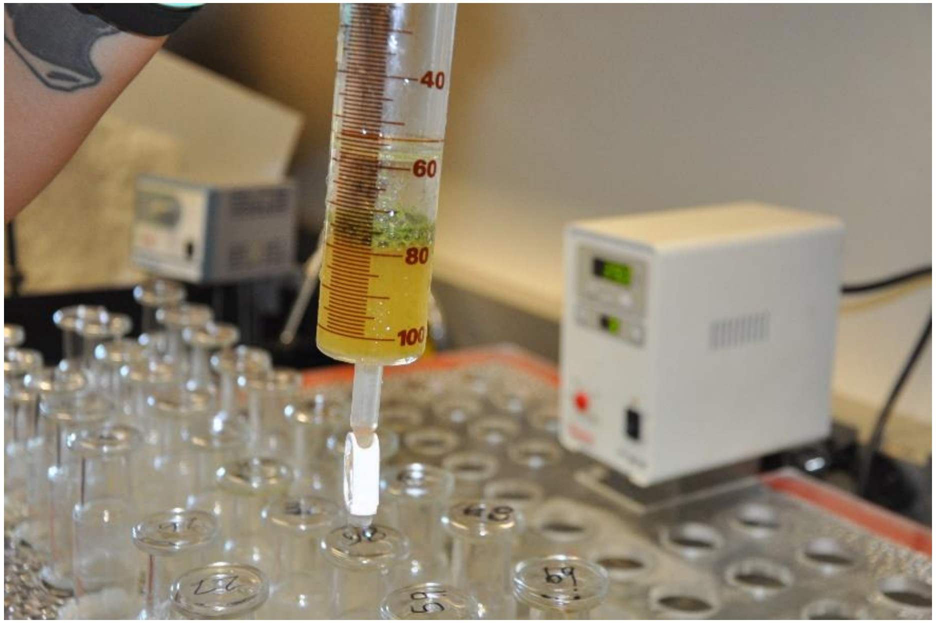


<u>**Extent**</u>**: Pure > Total.** <u>**Rate**</u>**: Pure (7.8%/h) > Total (5.5%/h)**

In Sacco NDF Disappearance



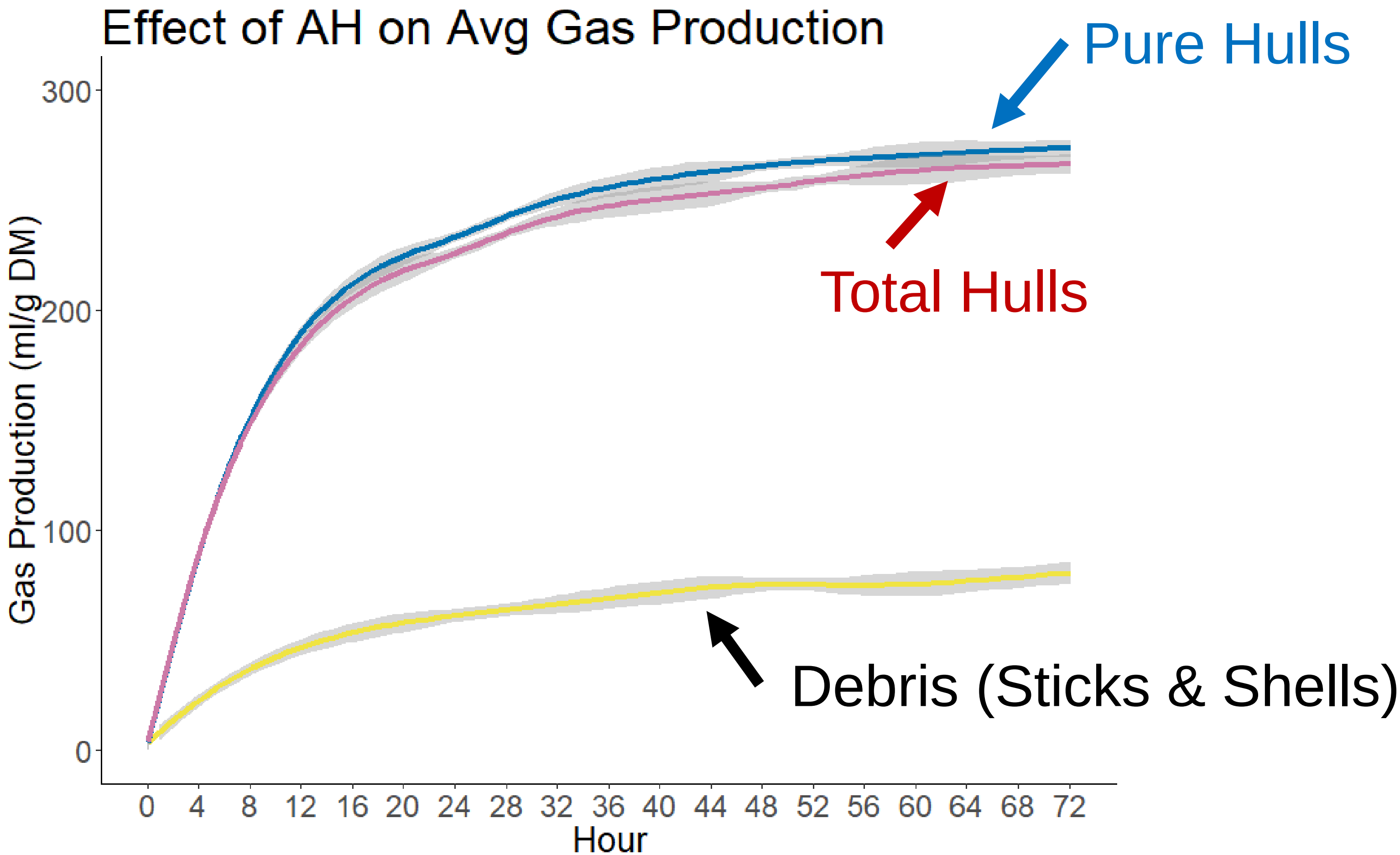
<u>Extent</u>: Pure > Total. **<u>Rate</u>: Pure (6.2%/h) > Total (5.7%/h)**



Approaches

- **Commercial (TAH) versus Pure AH (PAH)**
  - ***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



<u>Extent</u>: Pure (270 ml) > Total (268 ml) > Debris (79 ml)

<u>Rate</u>: Pure = Total (10%/h) > Debris (7%/h)

ME (Mcal/kg) from *In Vitro* Gas Production

	TAH	PAH	Debris
Nonpareil	2.14	2.23	1.13
Other	2.04	2.07	0.91

Feed	ME (Mcal/kg)
Almond hulls	1.85
Corn silage	2.67
Alfalfa hay (28 ADF)	2.49

NRC 1989

In vitro %DM Digestibility (Ankom Daisy)

	TAH	PAH	Debris
12 hr	79	81	36
24 hr	**84**	**87**	**37**
48 hr	**87**	**91**	**40**
72 hr	**88**	**92**	**42**

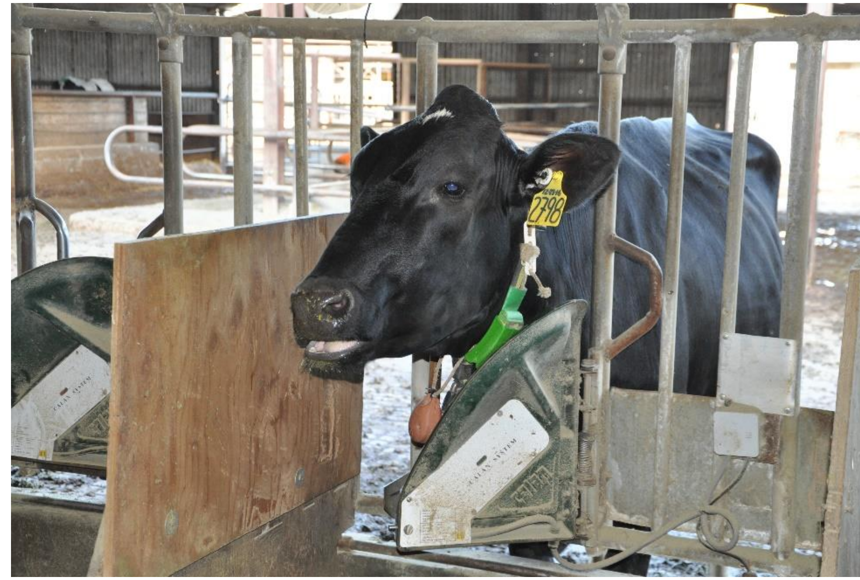
Pure Almond Hulls (PAH) > Total Almond Hulls (TAH)

In vitro %NDF Digestibility (Ankom Daisy)

	TAH	PAH	Debris
12 hr	14	11	6
24 hr	32	36	8
48 hr	**46**	**57**	**11**
72 hr	**51**	**61**	**13**

Pure Almond Hulls (PAH) > Total Almond Hulls (TAH)

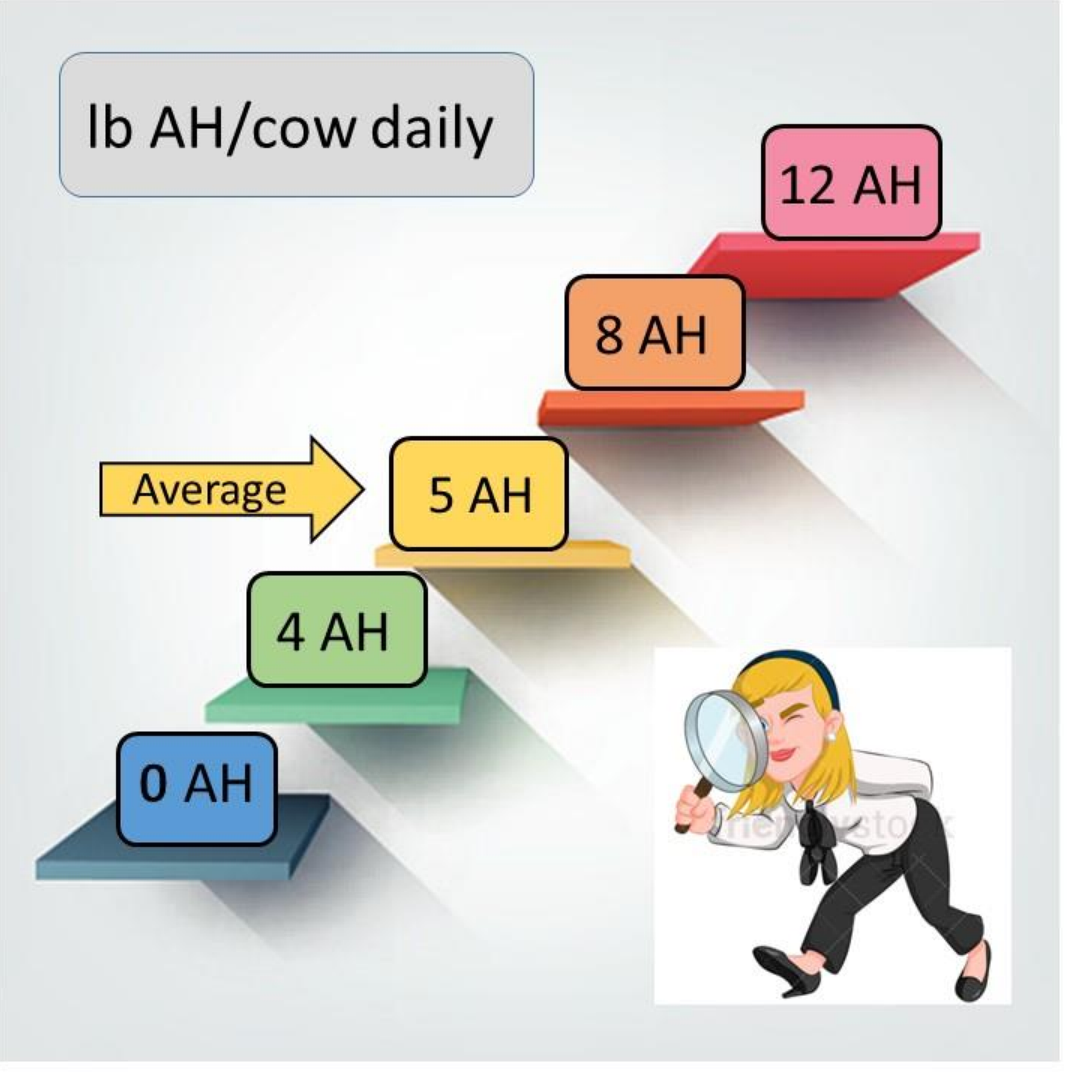
Feeding Value of Almond Hulls



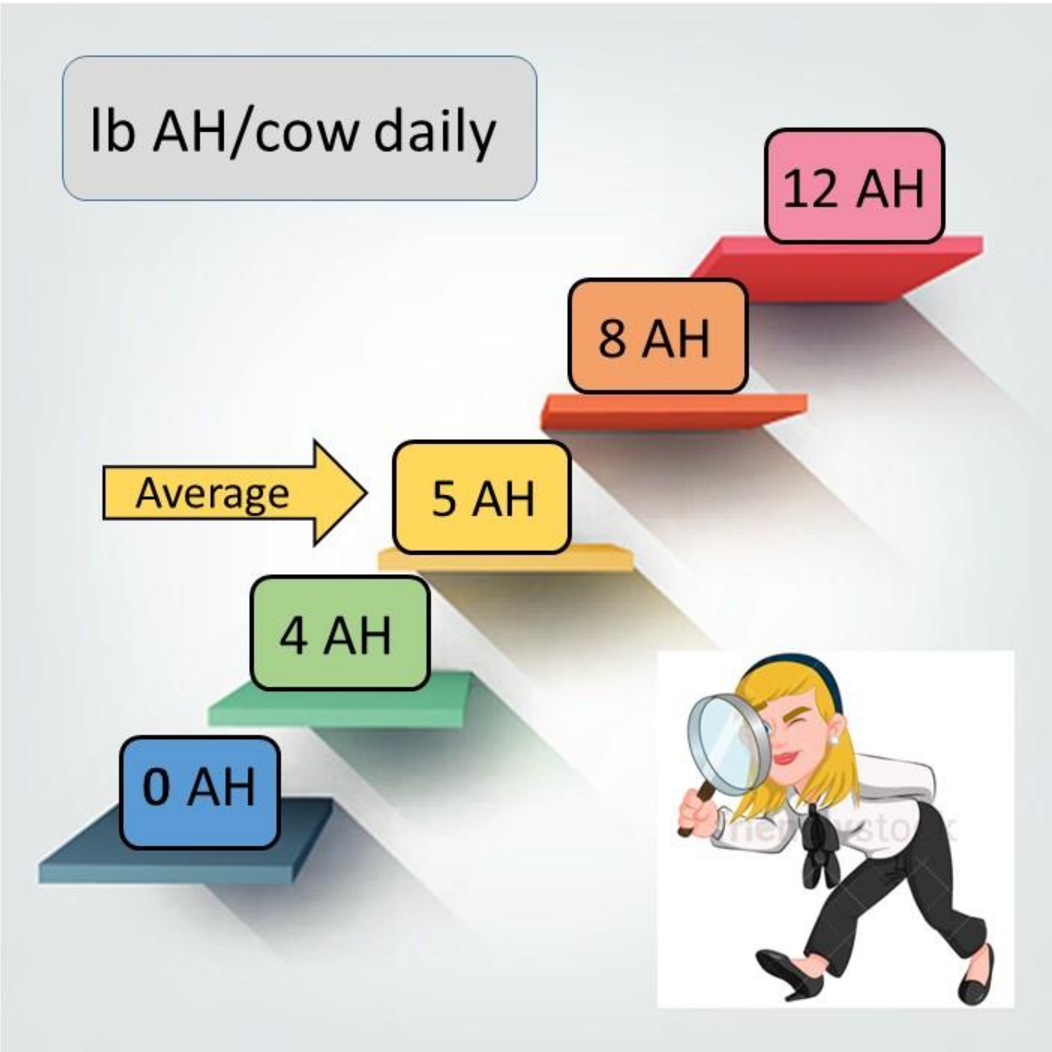
Objectives

- (1) Determine the impact of foreign debris material, shells and sticks, on the quality (chemical composition & digestibility) of almond hulls. ***"Variability in Composition"***
- (2) Evaluate feeding **high amounts** of almond hulls (AH) as a <u>concentrate</u> ingredient to lactating cows.

Objective of the Lactation Study



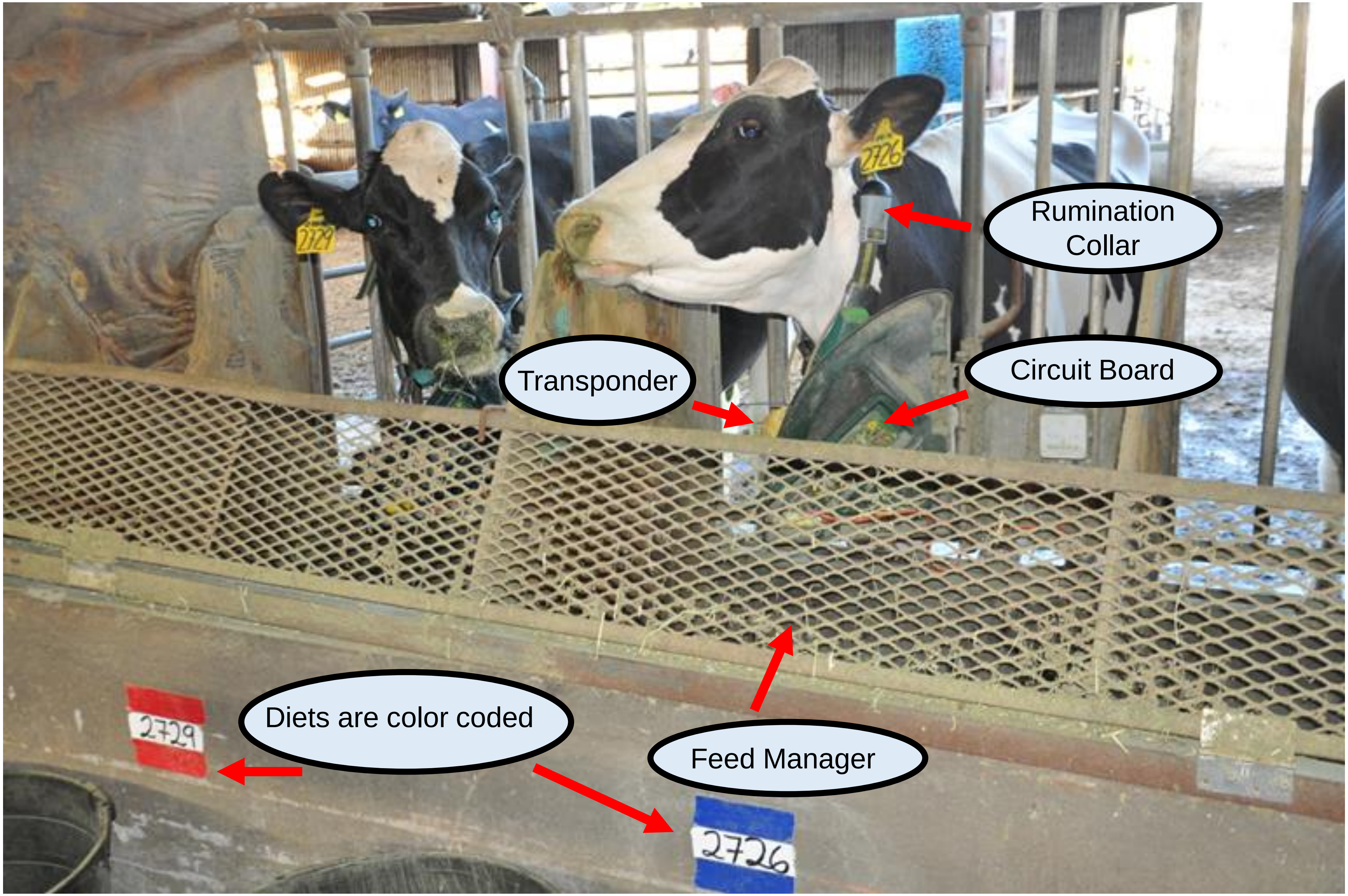
Objective of the Lactation Study



Lactation Study

- 12 lactating Holstein cows (96 DIM)
  - 4 1^{st} , 4 2^{nd}, 4 3^{rd} lactation cows
- Treatments: 0, 4, 8, or 12 lb AH/cow daily

  Really 0, 7, 13, or 20% TMR DM
- Production performance: milk yield, milk composition & component yield, feed intake, rumination activity, and diet digestibility.



Each cow was trained to eat from 1 assigned manger. Transponder allows her into her manager. Rumination collar measures rumination (cud chewing).

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. AH used as a concentrate ingredient.

Composition of Almond Hulls

Variation

Item	Mean	SD	Minimum	Maximum
CF, %	14.9	1.77	13.8	17.5
Lignin, %	7.2	0.78	6.3	8.1
CP, %	4.5	0.24	4.2	4.7
EtOH CHO, %	32.0	2.16	29.7	34.1
H_2O CHO, %	34.7	2.24	31.8	37.2
aNDFom, %	23.5	2.08	21.9	26.4

CF As Is basis = 12.8%

$\boxed{\leq 15\% \text{ definition}}$

Variation

N = 4 samples

Summary Production

No Difference in Feed Intake and Milk Yield

Item	0 lb AH	4 lb AH	8 lb AH	12 lb AH
DM Intake, kg/d	26.7	27.3	26.4	26.6
Milk, kg/d	38.8	39.3	36.9	37.7
ECM, kg/d	41.8	42.2	40.1	41.0

AH = Almond hulls

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

Milk Yield – Energy Corrected

ECM (kg/d)	0 lb AH	4 lb AH	8 lb AH	12 lb AH
Parity 1	37.3	38.5	34.5	37.1
Parity 2	40.1	39.8	39.1	40.1
Parity 3	46.9	48.2	46.8	45.8
Overall	41.8	42.2	40.1	41.0

No Significant Difference

Summary Production

Milk Composition Differed

Item	0 lb AH	4 lb AH	8 lb AH	12 lb AH
ECM, kg	41.8	42.2	40.1	41.0
Fat, %	3.81[a]	3.78[a]	3.95[b]	3.97[b]
Fat, kg	1.46	1.47	1.44	1.48
Protein, %	3.46[a]	3.43[a]	3.35[b]	3.33[b]
Protein, kg	1.33[a]	1.34[a]	1.23[b]	1.25[b]

As the amount of almond hulls consumed increased from 0 to 12 pounds/cow daily:

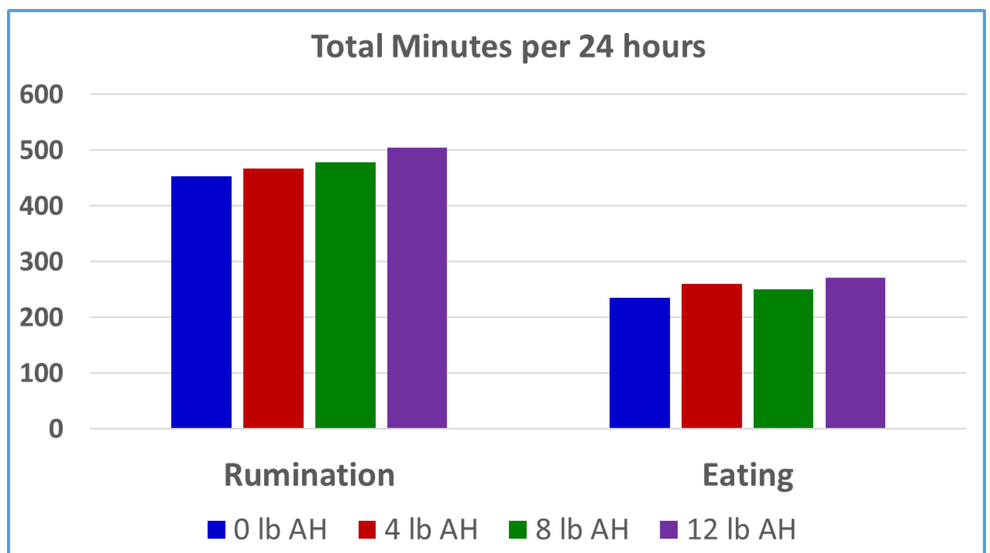
- Milk fat % increased
- Milk protein % & kg decreased

Summary Production

Milk Composition Differed

Item	0 lb AH	4 lb AH	8 lb AH	12 lb AH
EC Milk, kg/d	41.8	42.2	40.1	41.0
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

60 minutes more chewing so more stable rumen environment.



Production Performance: Aguilar et al. (1984)

Item	Control	12.5% AH	25% AH
DMI, kg/d	19.4	20.1	19.8
Milk, kg/d	25.3	25.5	24.8
Fat, %	3.2	3.2	3.2
Protein, %	3.2	3.2	3.2
SNF, %	8.8	8.8	8.8
Solids, %	12.0	12.0	12.0

No difference in performance with almonds hulls of 29% ADF and 30% soluble sugars.

Calculated Apparent Digestibility (Sheep)

Item	Almond Hulls	Alfalfa Hay
DM, %	60.9	63.3
aNDFom, %	23.5	44.4
ADFom, %	17.7	45.6
Crude Protein, %	32.6	73.7

Almond Hulls : Alfalfa Hay → 0:100, 10:90, 20:80, 40:60

Limitations: Only evaluated 1 lot of commercial almond hulls. Regression analysis approach limits the number of almond hull samples used in a digestion study.

Calculated Apparent Digestibility (Steers)

Aguilar et al. (1984)

Item	Nonpariel	Neplus	Commercial
DM, %	61.2	62.1	59.6
ADF, %	19.4	23.3	14.8
Energy, %	57.0	56.3	54.5
DE, Mcal/kg	2.52	2.45	2.38

Control diet contained forage and concentrate with almond hulls in the ratio of
Almond Hulls : Control → 0:100, 20:80, 40:60

Calculated Apparent Digestibility (Steers & Sheep)

Item	**Nonpareil**	**Neplus**	**Commercial**	**Commercial**
ADF, %	19.4	23.3	14.8	17.7

Steers **Sheep**

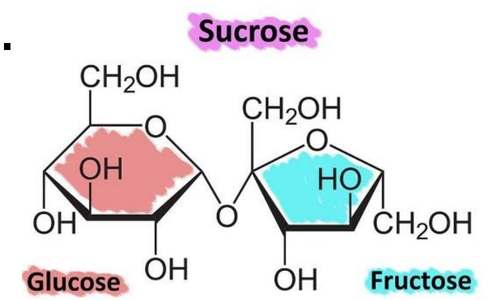
Fiber in almond hulls may not be as digestible as some people think.
However, we did not see a decrease in fiber digestibility in our lactation study.


Dairy Magazines
Almond hulls: replacing starch from corn with sugars from hulls pg 32
Almond hull fiber replacing corn silage in dairy diets pg 64

Replacing Starch with Sugar Thoughts

- Changing nonstructural carbohydrate source (sugar vs starch) impacts the rumen microbial community. Not feeding the cow – we are feeding the microbes.
- Sugars are fermented more rapidly than starch.
- Type of sugar appears to have an impact.
- ***In vitro*** rumen fermentation studies tend to show **<u>increased</u> <u>butyrate</u> <u>concentration</u>** with sugars. For example, replacing corn starch with sucrose increased molar concentration of butyrate.
- ***In vivo*** studies are **<u>not</u>** as definitive as *in vitro*: increased, no change, and decreased molar proportion of butyrate in rumen fluid were reported.

Fructose & Xylose $\longrightarrow$ Propionate
Sucrose & Lactose $\longrightarrow$ Butyrate



Replacing Starch with Sugar Thoughts

- Oba (2011) stated in a review "*Collectively, there is little evidence in the literature to support the concept that increasing dietary sugar concentration decreases rumen pH*".
- Whoa – different than what I originally thought!
- Oba (2011) reported: research supports that feeding high sugar diets increases milk fat production.
- **If rumen butyrate is increased with feeding of sugars, butyrate is a substrate for milk fat de novo synthesis so this could explain the increased milk fat % we observed with increasing almond hulls in the diet.**

Diet Composition (%): Williams et al. (2018)

Item	Control	Almond Hull
Corn grain	26.4	26.4
Canola Meal	8.8	8.8
Vit/Min	0.88	0.88
Alfalfa Cubes	63.9	46.3
Almond Hulls	0	17.6

Production Performance

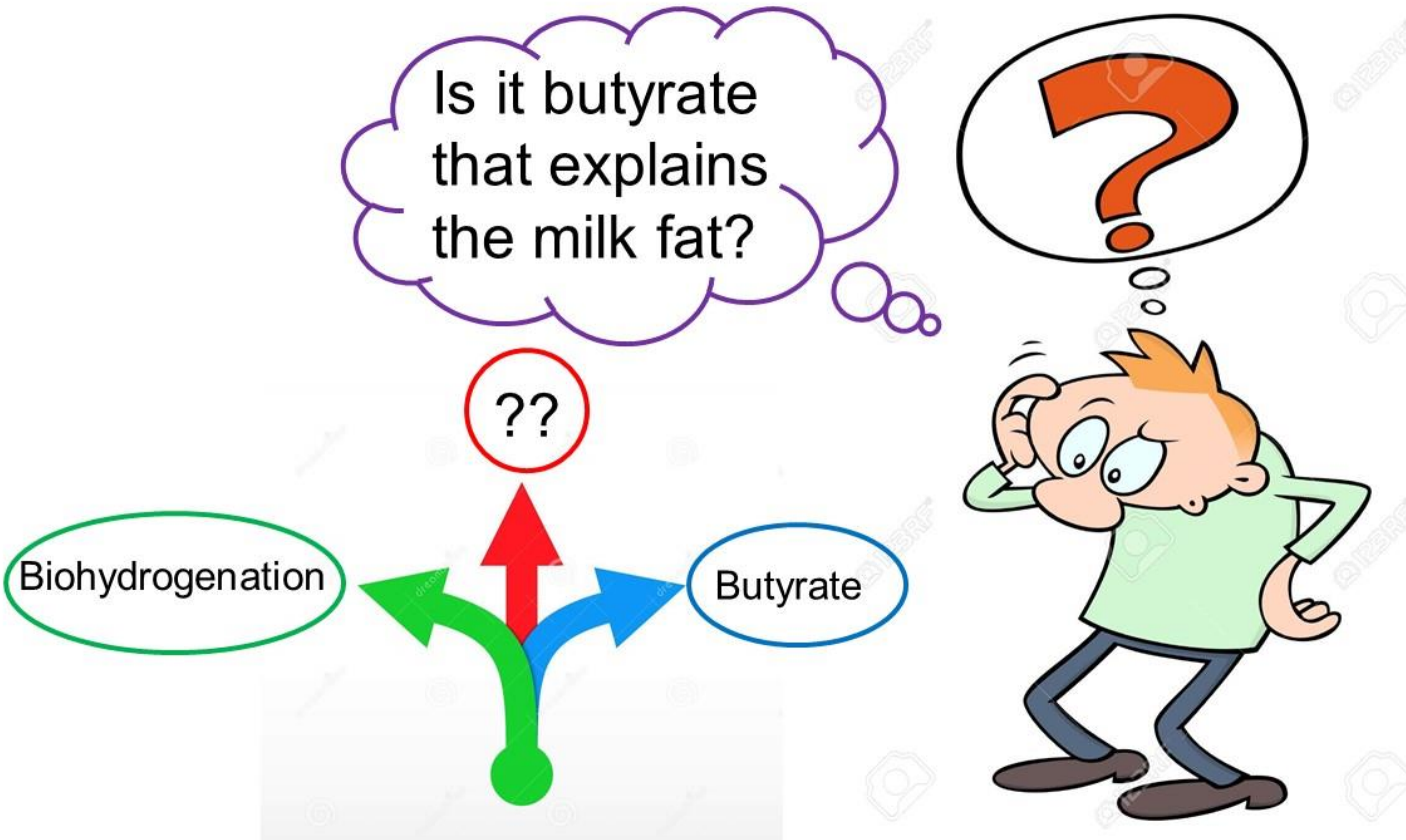
Williams et al. 2018

Item	Control	Almond Hull
DMI, kg/d	22.3	22.6
Milk, kg/d	27.4[a]	24.6[b]
ECM, kg/d	26.4[a]	24.6[b]
Fat, %	3.81	4.14
Fat, kg/d	1.04	1.00
Protein, %	3.22	3.20
Protein, kg/d	0.87[a]	0.78[b]

Rumen Data: Williams et al. 2018

	Control	Almond Hull
Rumen fluid pH	6.2	6.3
Rumen NH3, mg/L	218[a]	170[b] ↓
Acetate, mM	65.7[a]	67.3[b] ↑
Propionate, mM	21.3[a]	18.1[b] ↓
Butyrate, mM	9.46[a]	11.2[b] ↑
Valerate, mM	1.71	1.62

Rumen protozoal populations affected


Is it butyrate that explains the milk fat?
??
Biohydrogenation
Butyrate

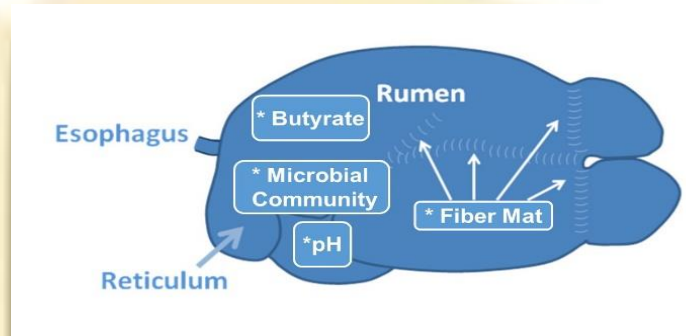
More

to the

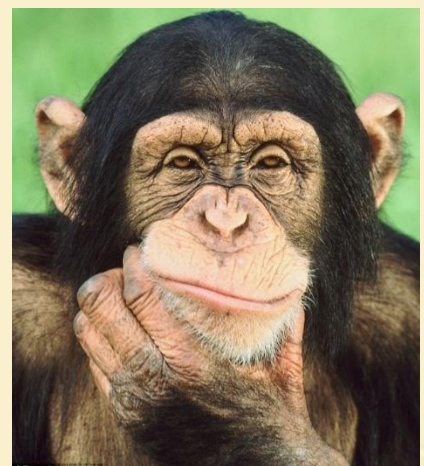
Story

in the

Future



Maybe Something to Think About!



Composition
&
Regulatory
Issues

Center for Analytical Chemistry

cdfa

Inspection Services

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

Karen Ross, Secretary

July 11, 2019

NOTICE TO INDUSTRY

Almond Hull Products Compliance

The California Department of Food & Agriculture's Commercial Feed & Livestock Drug Program is reminding the almond hull industry of the program's compliance plan regarding all almond hull, and almond hull and shell crude fiber violations. This is a result of the high violation rate (over 60 percent) of crude fiber on over one-hundred official samples of almond hulls from the 2018 crop year. This is being implemented to increase compliance and reduce the official sample violation rate for products defined in the California Code of Regulations (CCR), Section 2273.5. Almond Hulls, and will remain in effect until further notice.

Commercial Almond Hull Feed Inspections

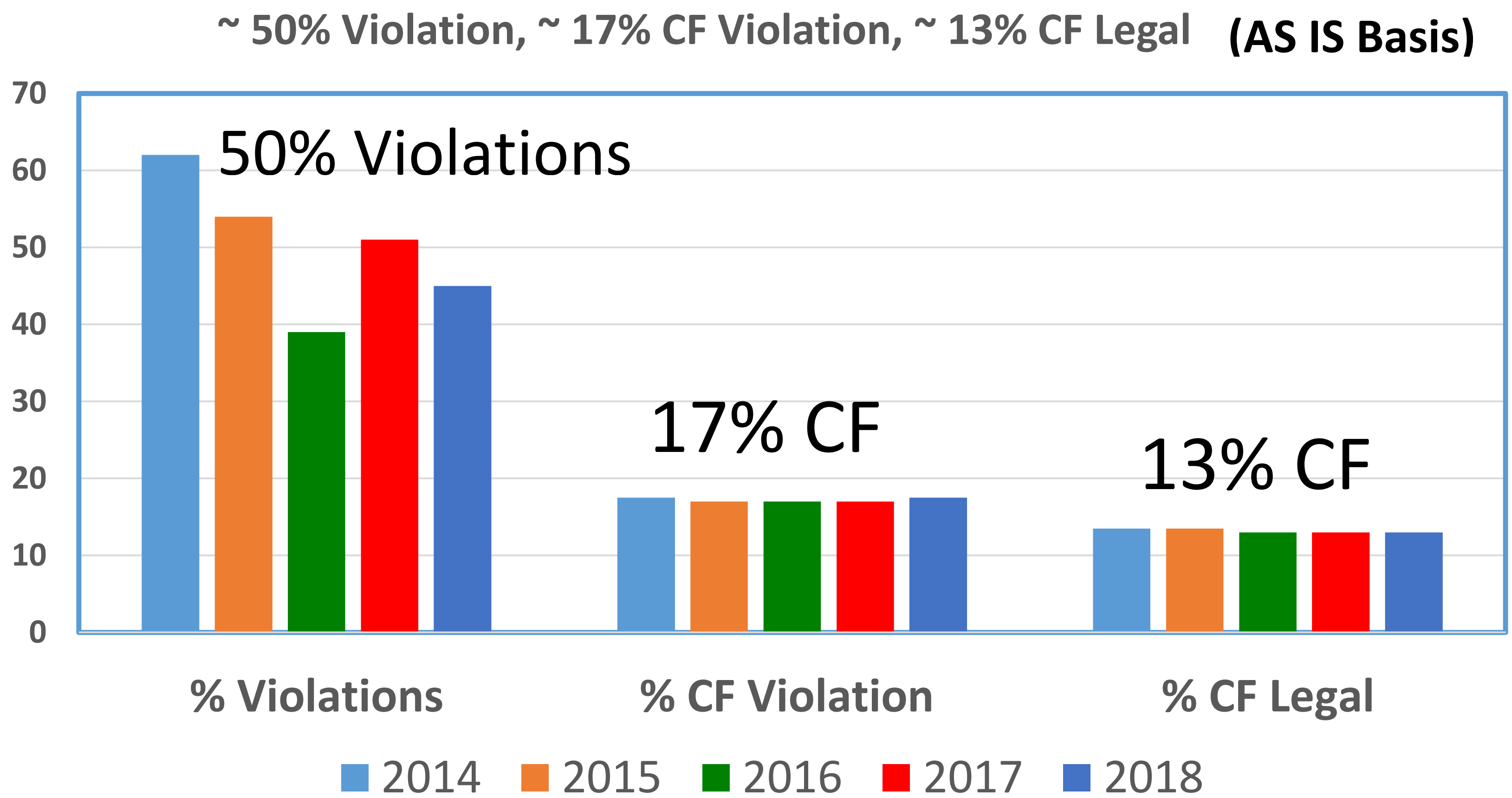
- Evaluated the **data for a 5-year period** from the CA Department of Food & Agriculture for samples of commercial almonds collected by Field Inspectors.
- These samples of commercial almonds were analyzed for crude fiber and moisture. **Retrospective Analysis**.
- **<u>Aim</u> was to determine what proportion of samples collected were found to be in violation of commercial feed laws/regulations.**

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

Almond hulls are defined in CA by commercial feed laws: “They shall not contain more than 13.0 percent moisture, **nor more than 15.0 percent crude fiber**, and not more than 9.0 percent ash.”

Violation for Almond Hulls

<u>Findings</u>: On average **50%** of the almond hulls sampled were in violation. Hulls in violation average 17% crude fiber.



Almond Hulls must be ≤ 15% Crude Fiber As Is basis

Don’t Guess - Test

Smaller hulls

More Shell

Larger sticks

Dairy X

Dairy UCD

Composition and Regulatory Issues

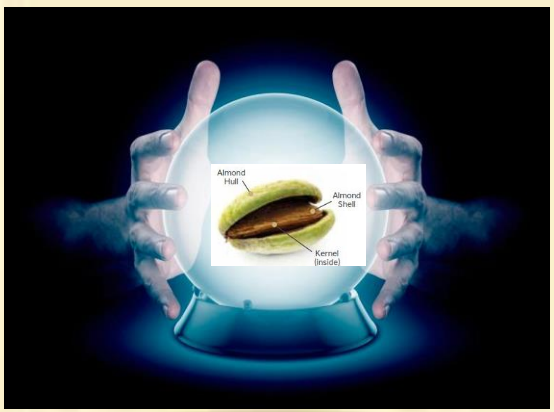
Take Home Messages

Almond hulls had a high rate of violations related to crude fiber content but not moisture content.

Almond hulls found in violation averaged 17% CF while hulls not found in violation average 13% CF.

Test, Don't Guess! when it comes to almond hull quality.

Current & Future Research



What does the future hold?

Current Research

- Chemical Composition study for 2021 harvest season.
- Total Almond Hulls and Pure Almond Hulls.
- Wet Chemistry and NIR Analysis.
- Measuring ADL (acid detergent lignin) and KL (Klason lignin). Sequential fiber – pectin.
- *In vitro* digestibility.
- Lactation Study with cubes containing almond hulls and alfalfa hay.

Future Research

- Microbial community & microbial end-products.
- Almond hulls as a forage to replace silages.
- Chemical composition of almond hulls as it relates to current and future agronomic practices: age of orchard, pruning, “off ground harvesting”, other?
- Physical form of the almond hulls: pelleting or cubing.
- Other??

Take Home Messages

1. AH (high quality) can be fed at high levels to lactating dairy cows.
2. Composition – Varies Greatly!!
3. Test the composition of your AH

   "Don't Guess - Test"
4. AH are an excellent source of readily available carbohydrates (sugar) and digestible fiber.
5. More information to come in the future!

"Thank You"

*** CANC 2022 Program Committee**
*** Almond Board of CA**
- Biomass Workgroup
(almond handlers & growers)

The End

QUESTIONS ??

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