

# Recent Advances in Nutrition that have Impacted Production Efficiency



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# **Why is Food / Meat Production Efficiency of interest?**

## **Sustainability of Human Life**

### **1. Affordable supply of calories & nutrients.**

**1 Billion humans are near starvation today.**

**1 Billion humans are obese today.**

### **2. Available safe drinking water.**

### **3. Disease control / Health.**

### **4. Environmental sustainability.**

# Why is Food / Meat Production Efficiency of interest?

## Sustainability of Human Life

	<b>Poor</b>	<b>Rich</b>
<b>Food supply</b>	Quantity	Quality
<b>Water supply</b>	Varies	Low
<b>Human health</b>	Low	Varies
<b>Environment</b>	Low	Increasing
<b>Meat intake</b>	Increasing	Stable

# What Drives Food /Meat Production?

## Supply Drivers:

1. Economic return.
2. Governmental controls -  
Regulations / Taxation / Import & export
3. Retailer specifications.

## Demand Drivers:

1. Price & Availability.
2. Individual preferences.  
Where food is plentiful and low in cost:
  - Quality, Healthfulness,  
Environmental effects.

# Related Topic Reviews

**Annison, E.F., and W. L. Bryant. 1996. Perspectives on ruminant nutrition and metabolism. Nutr. Res. Rev. 11:173-198.**

**Firkins, J. L. et al. 2010. Integration of ruminal metabolism in dairy cattle. J. Dairy Sci. 89:E31-E51.**

**Firkins, J. L. et al. 2010. Ruminal nitrogen metabolism: Perspectives for integration of microbiology and nutrition for dairy. J. Dairy Sci. 90:E1-E16.**

**Kebreab, E. et al. 2011. Recent advances in modeling nutrient utilization in ruminants. J. Anim. Sci. 87:E111-E122.**

**How has diet composition changed?  
Why do diets differ in composition?**

**Surveys of Feedlot Diet Composition:**

# How has diet composition changed? Why do diets differ in composition?

## Surveys of Feedlot Diet Composition:

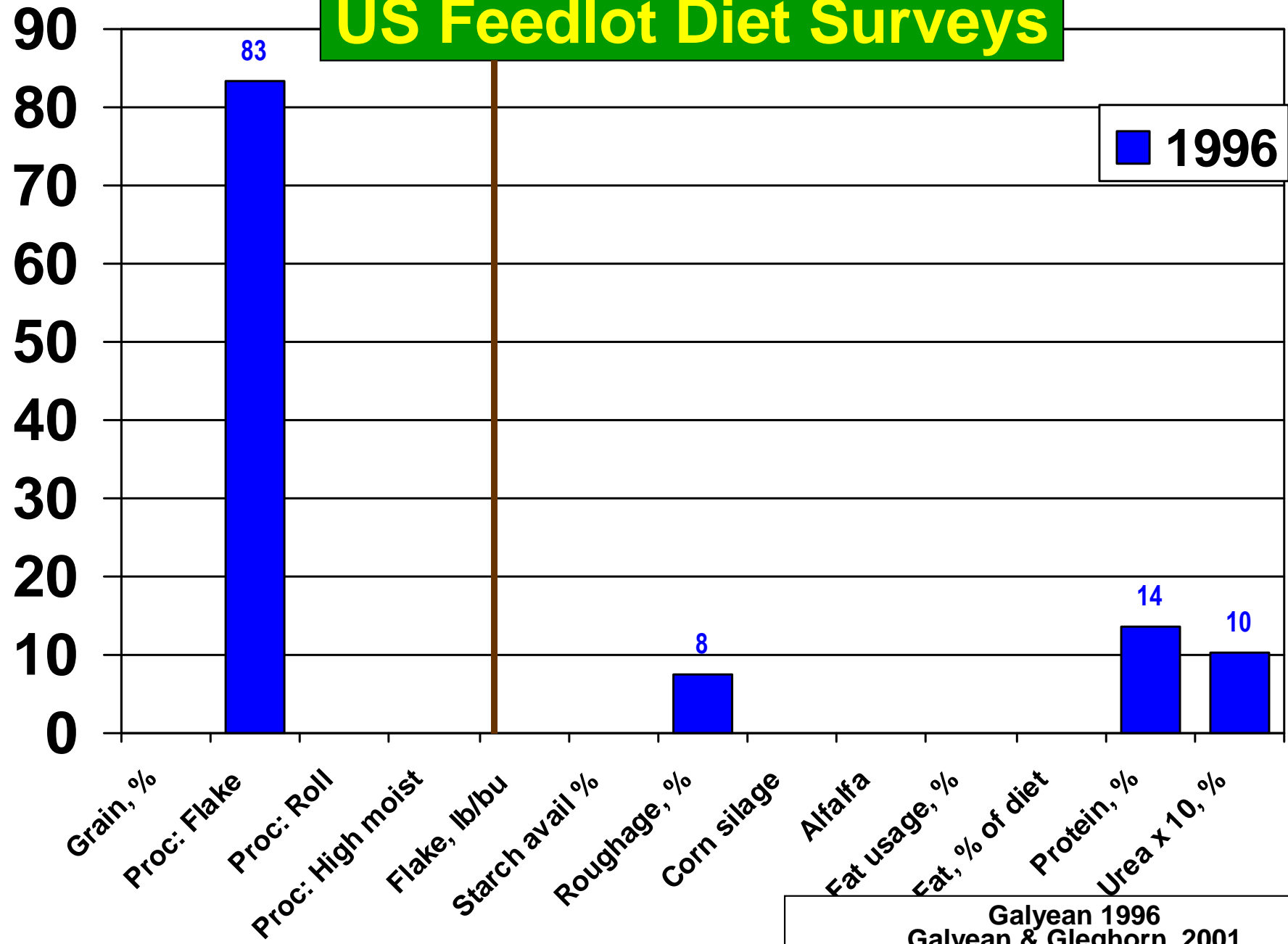
1996. Protein levels in finishing diets: Industry application. M. L. Galyean. J. Anim. Sci. 74:2860.

2000. Texas Tech Consulting Nutritionist Survey. Galyean & J. F. Gleghorn. Burnett Prog. Rep. 12.

2007. Texas Tech Survey. J. T. Vasconcelos & Galyean. J. Anim. Sci. 83:2772.

2009. Management practices in Brazil feedlots. D. D. Millen et al. J. Anim. Sci. 87:3427.

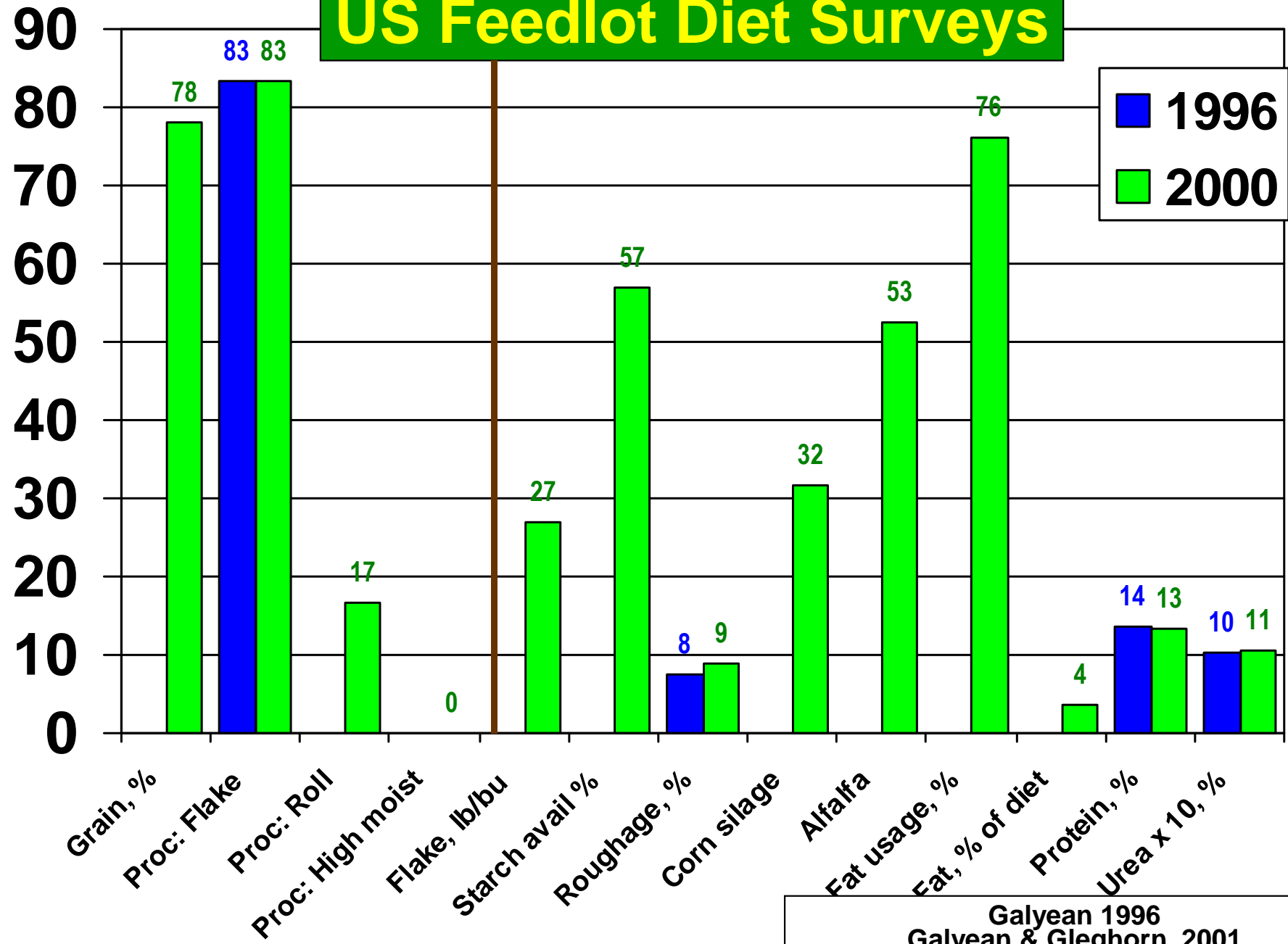
# US Feedlot Diet Surveys



■ 1996

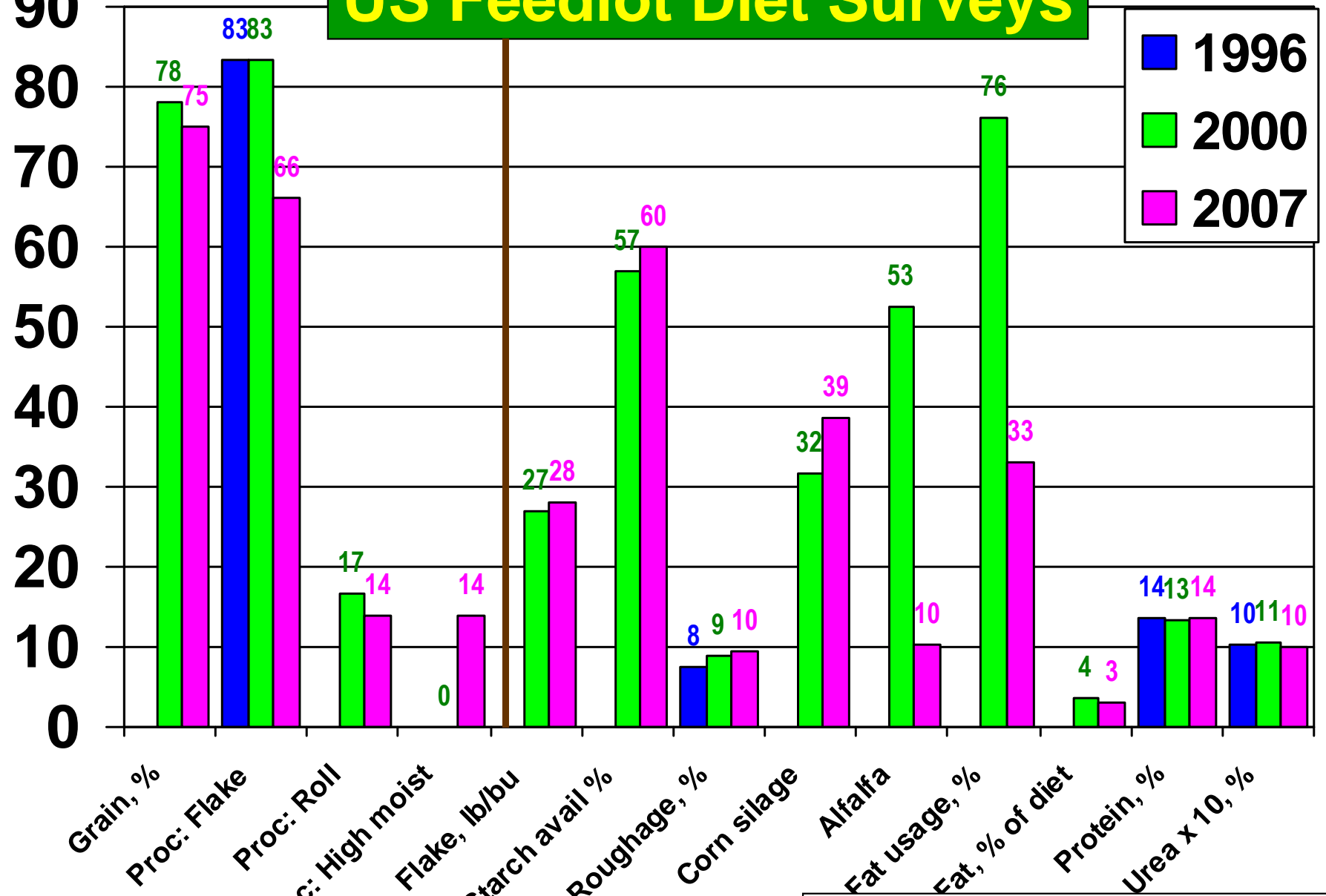
Galyean 1996  
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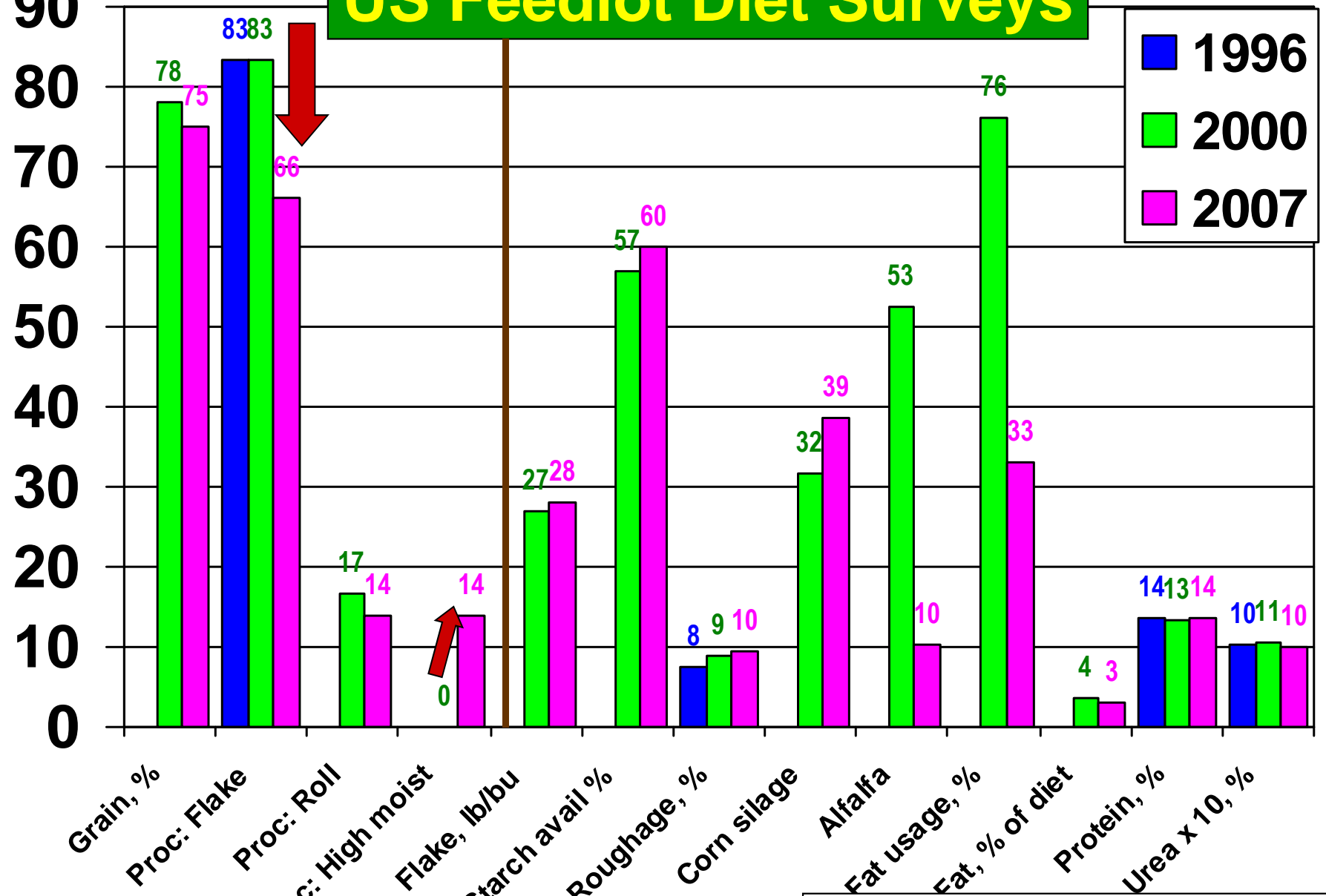
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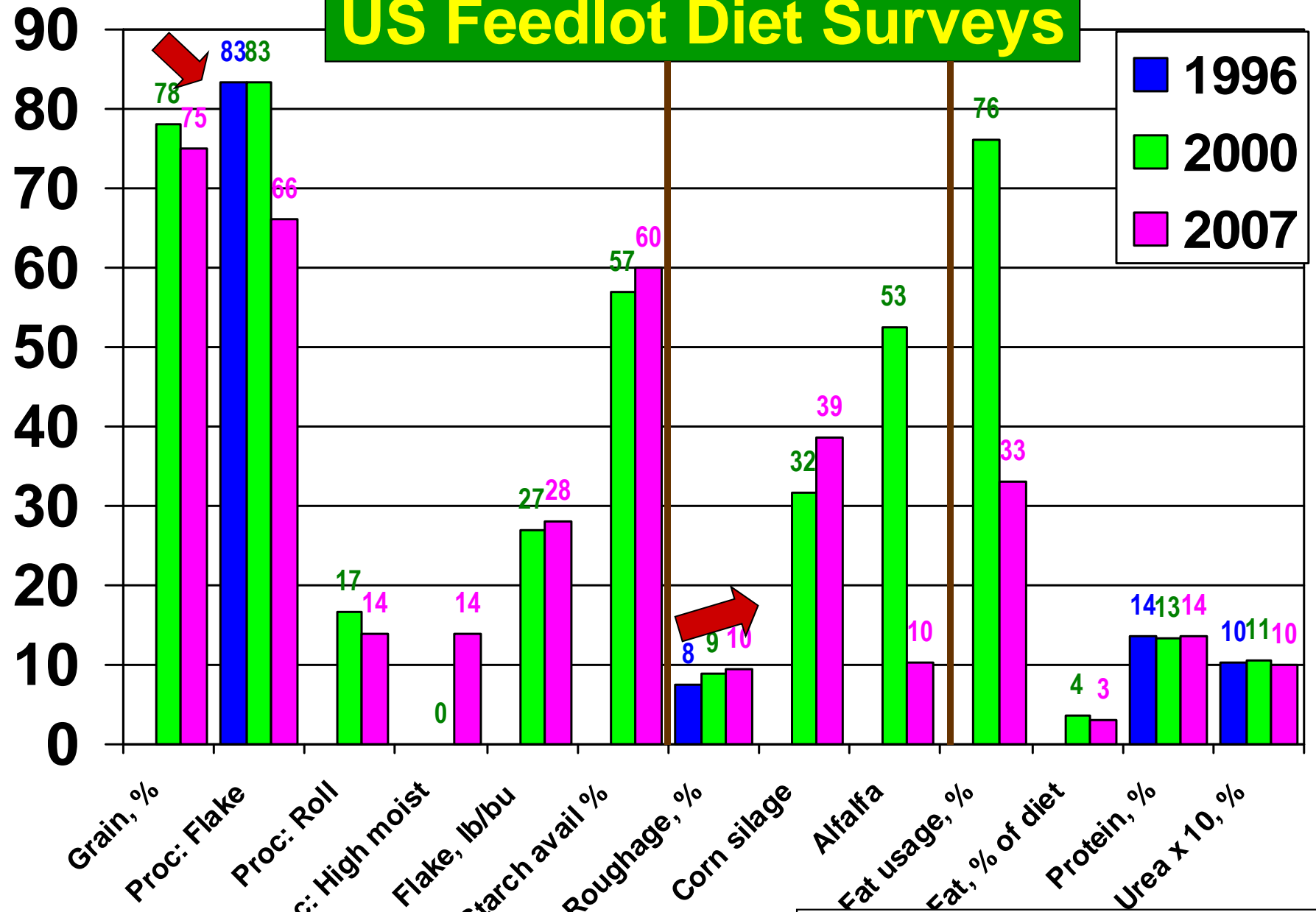
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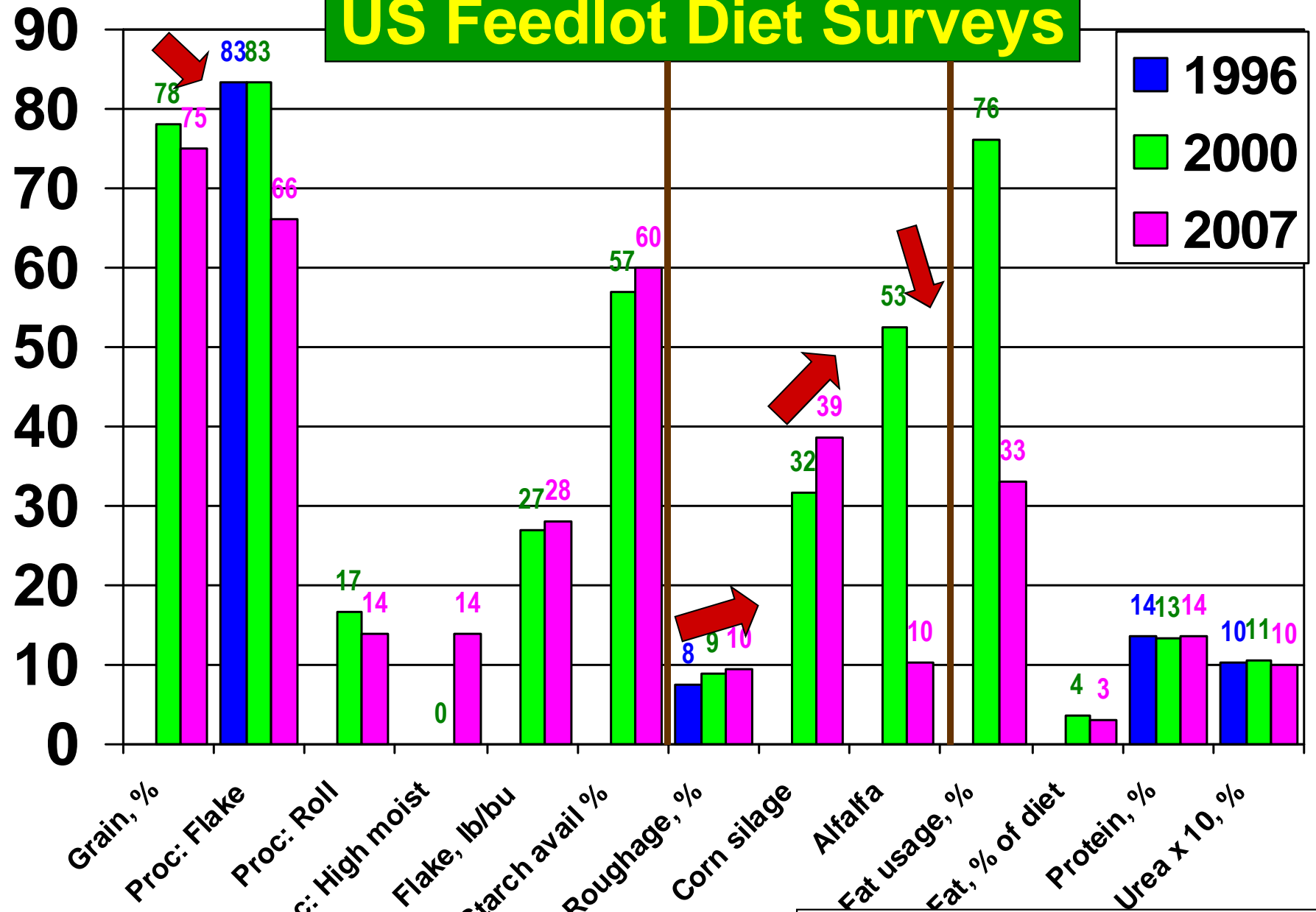
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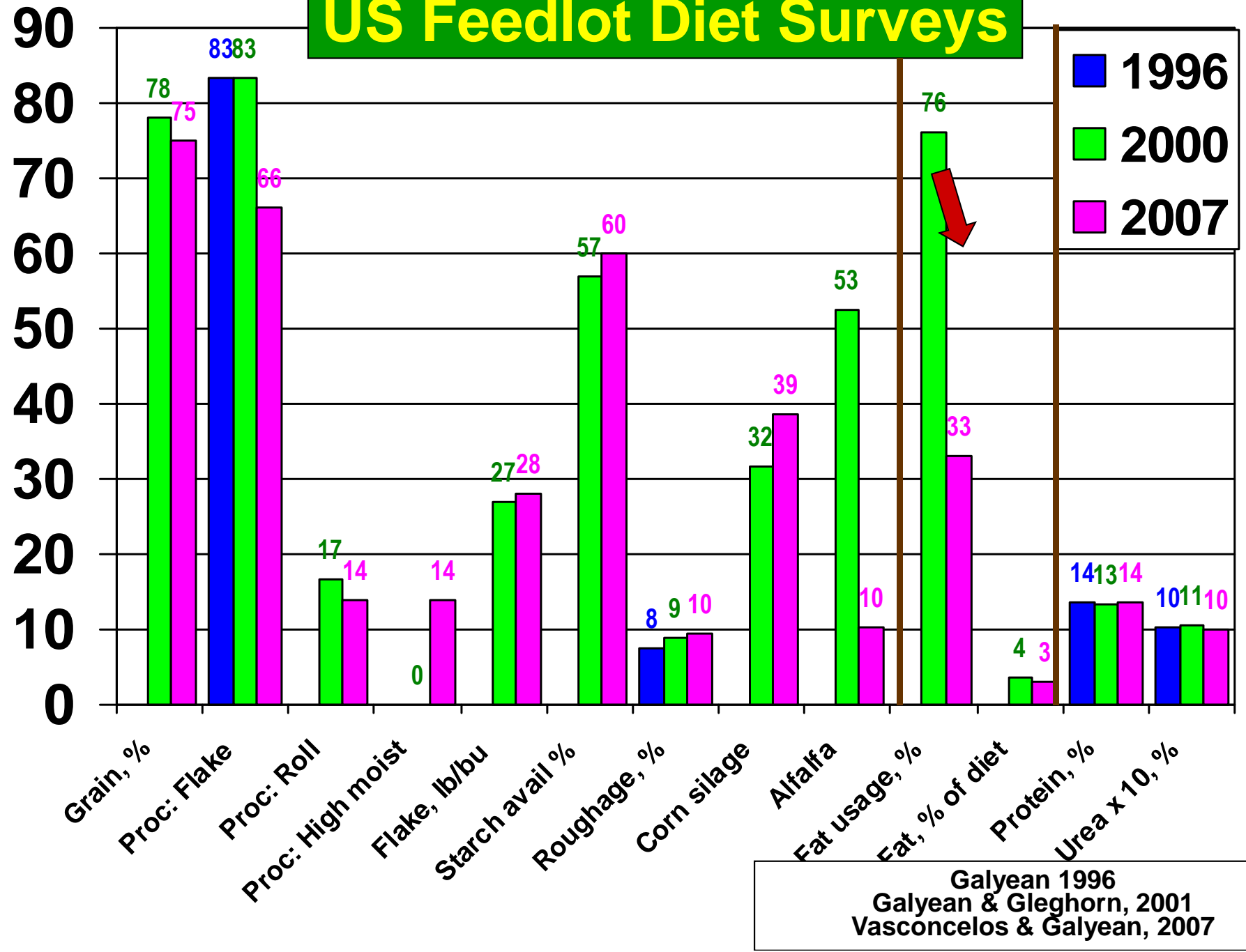
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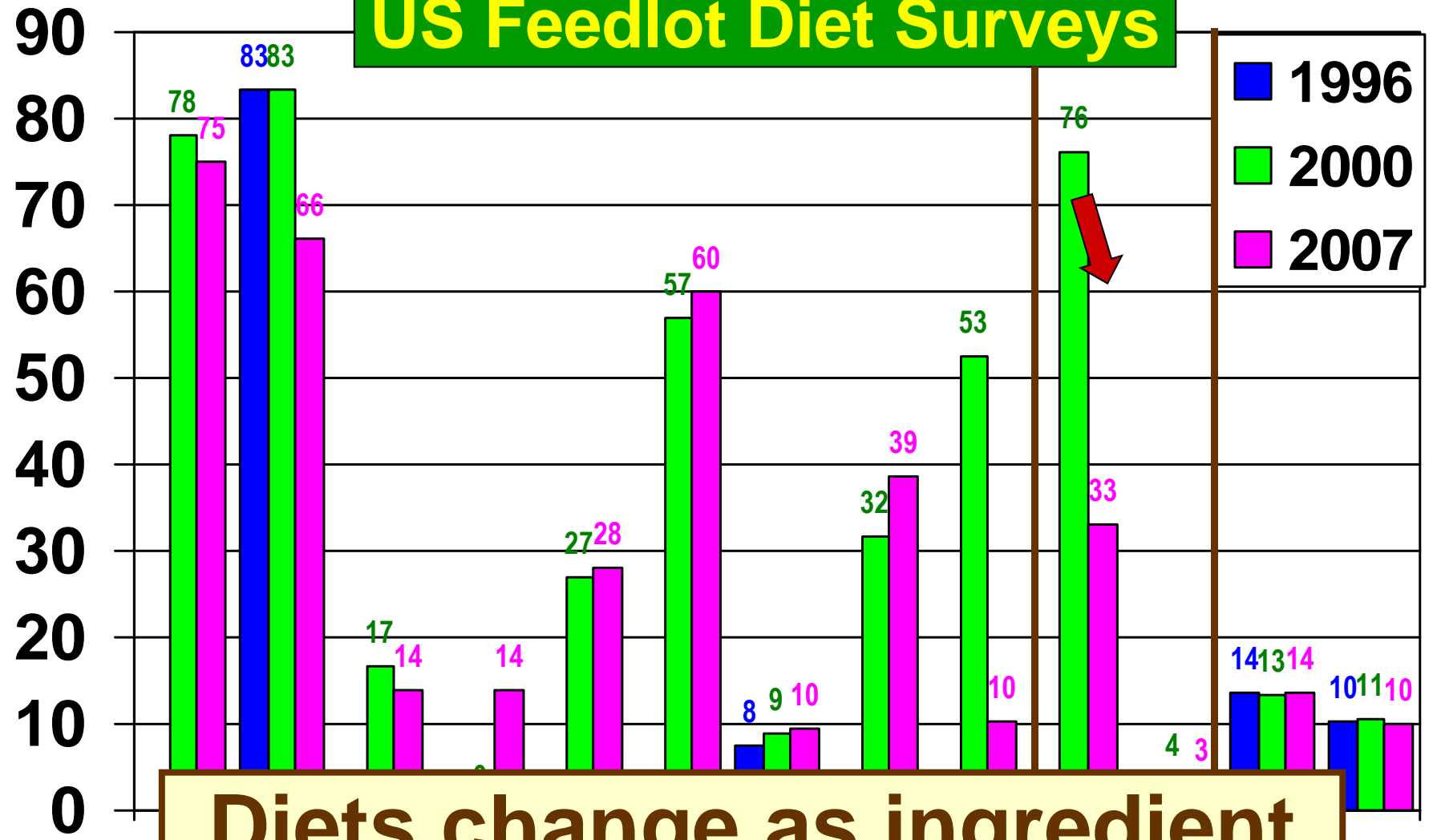


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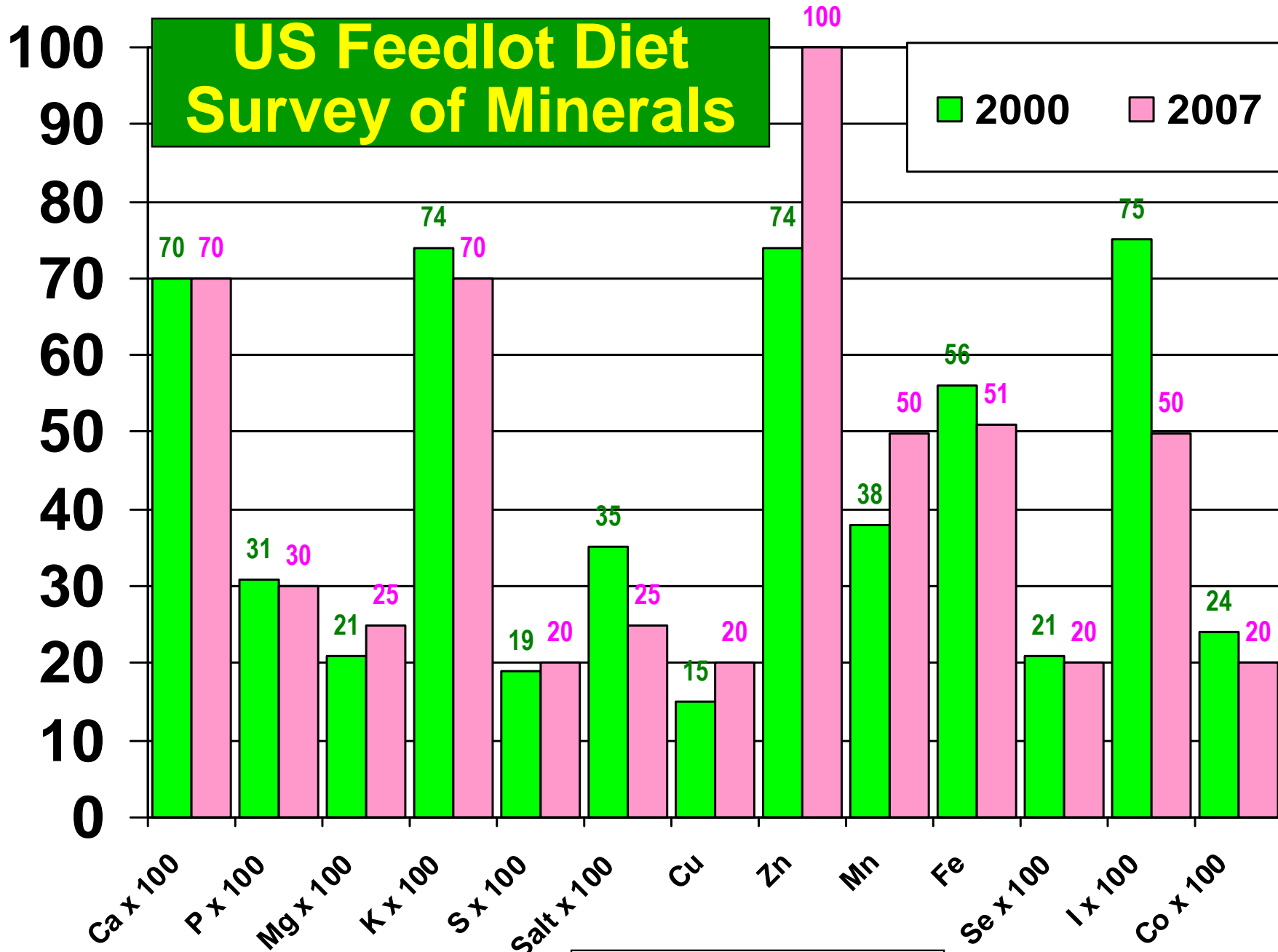
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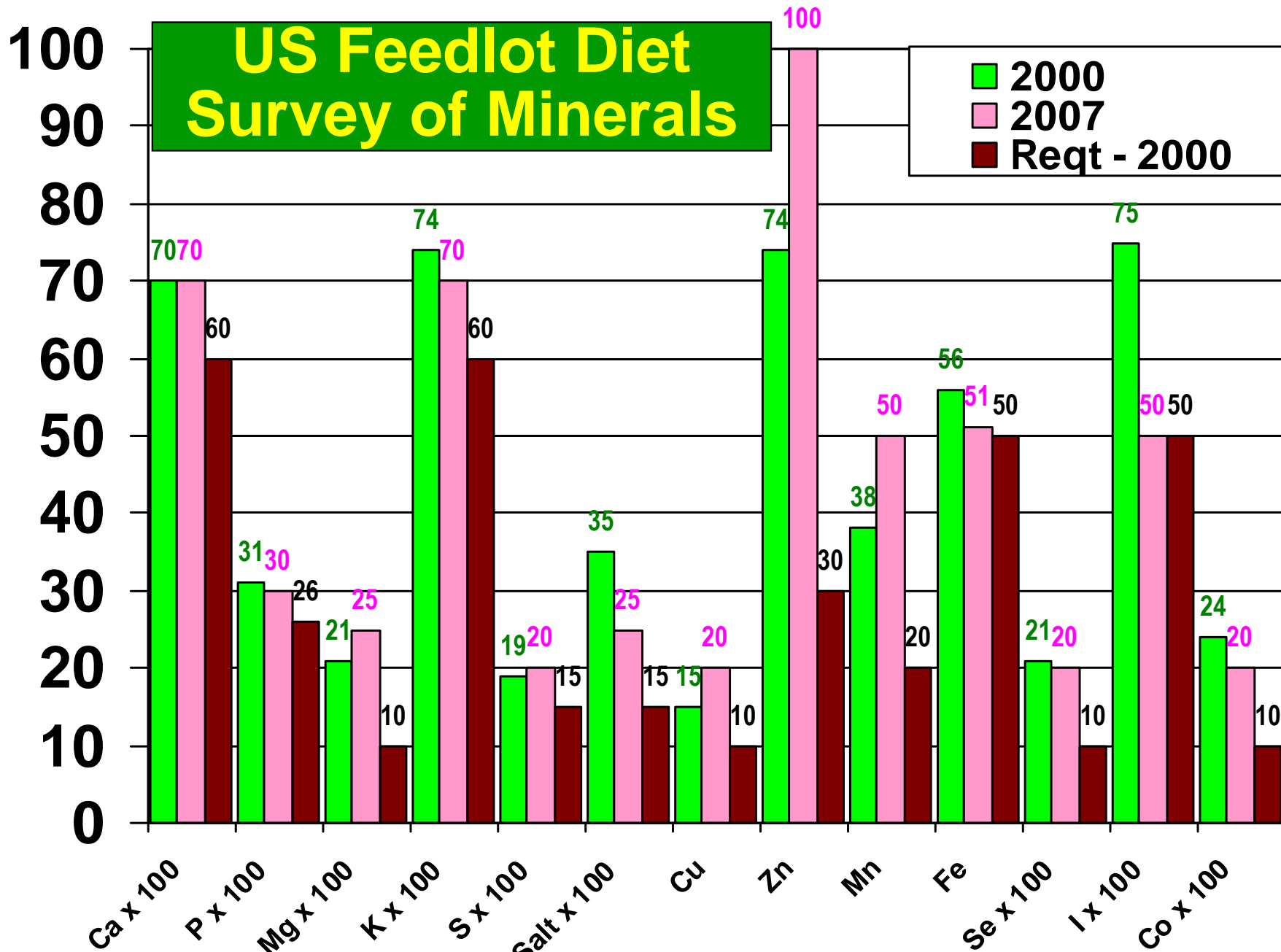
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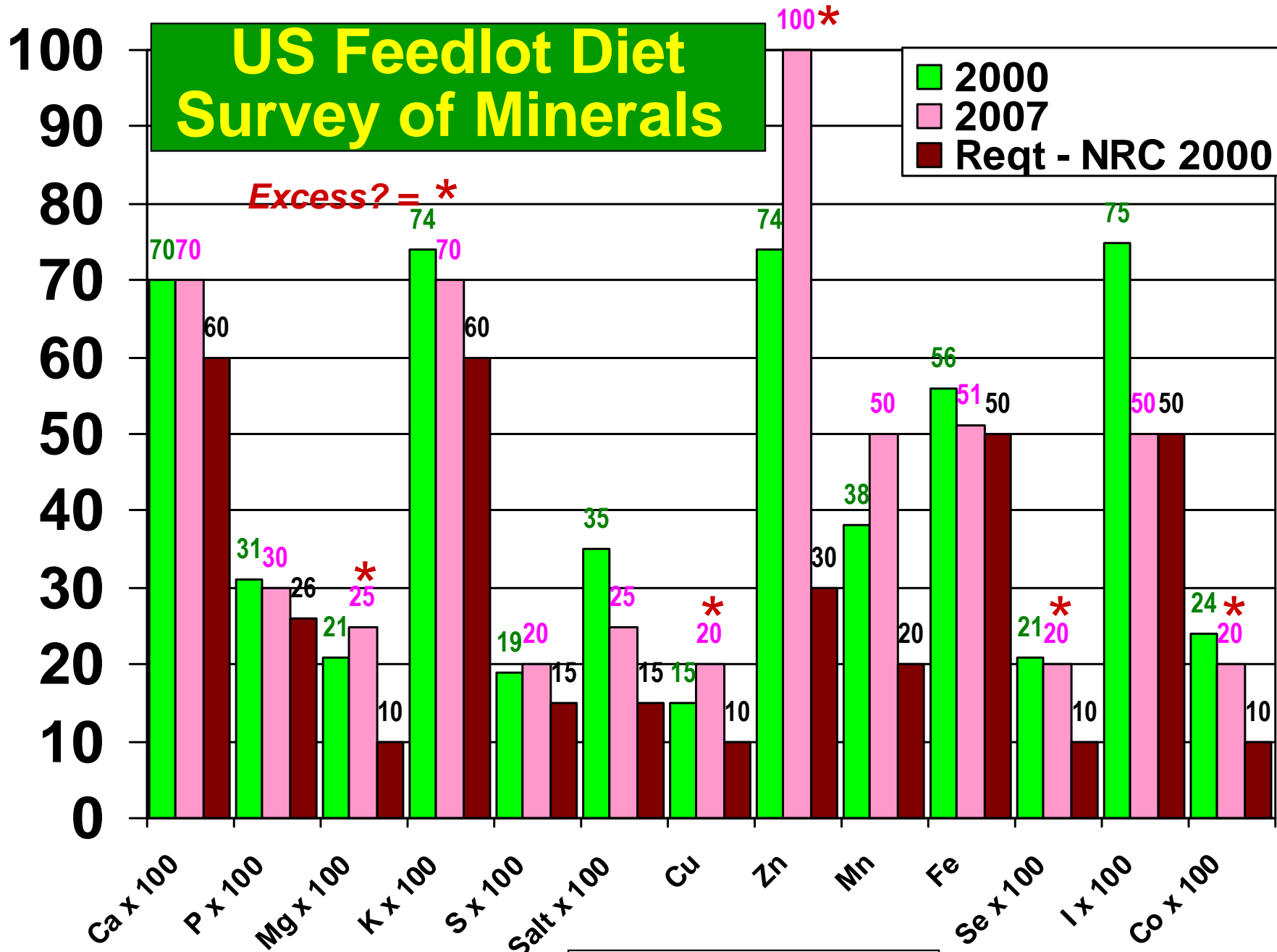
**Diets change as ingredient and processing costs change.**



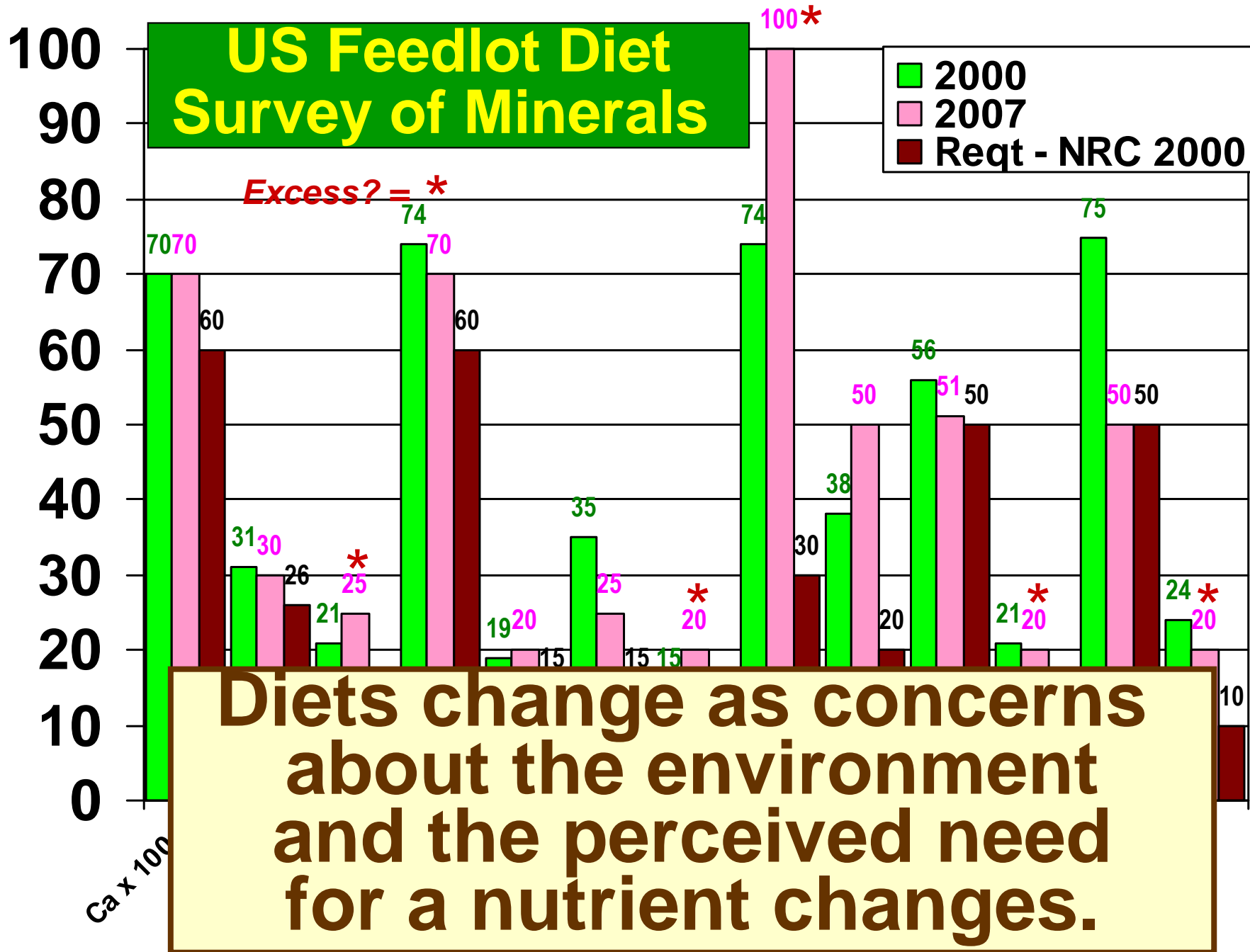
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# Other Diet Differences

	<u>1996</u>	<u>2000</u>	<u>2007</u>
<b>Primary grain</b>	<b>Corn</b>	<b>Corn</b>	<b>Corn</b>
<b>Second grain</b>	<b>Sorghum</b>	<b>Sorghum</b>	<b>Wheat</b>

# Other Diet Differences

	<u>1996</u>	<u>2000</u>	<u>2007</u>
Primary grain	Corn	Corn	Corn
Second grain	Sorghum	Sorghum	Wheat

Processing	<u>Flaked</u>	<u>Roll/Grind</u>	<u>Ensiled</u>
U.S. (2007)	66%	14%	14%
Brazil (2009)	0%	100%	0%

(Millen et al., 2009)

**Diets differ with feed costs and availability of equipment.**

# Dietary Ingredients Available

## Diet additives:

- Anionic salts and products
- Aspergillus oryzae
- Biotin
- Beta-carotene
- Calcium propionate
- Choline (rumen protected)
- Enzymes (fibrolytic)
- Enzymes (amylase)
- Essential oils (cinnamon, clove, garlic)
- Immune stimulant
- Magnesium oxide
- Methionine hydroxy analog
- Monensin
- Niacin (acid, amide)
- Prebiotics (Nonviable)
- Probiotics (Viable microbes)
- Propylene glycol
- Silage bacterial inoculants
- Sodium bentonite
- Sodium bi/sesquicarbonate
- Yeast culture and yeast
- Yucca extract
- Zinc methionine

**If each of these 23 additives increased efficiency by 4.4%, cattle would not need to eat any feed!**

# US Feedlot Additive/Implant Use

**Growth implants** 70-80%

Estrogen/Androgen/Combinations

**Ionophores** >90%

Monensin, Lasalocid, Laidlomycin

**Repartitioning agents** ?

Optaflexx, Zilmax

**Melengestrol acetate** ?

**Antibiotics** ?

**Probiotics** ?

# US Dairy Diet Ingredient Use (%)

	2006	2010	Change
Buffers	41	42	
Yeast/yeast culture	28	30	
Rumensin	15	21	+40%
Niacin	9	11	
Probiotics	11	13	
Mycotoxin binders	11	23	>100%
Methionine	6	9	
Anionic products	3	5	
Feed bunk stabilizer	2	3	
Don't use	11	9	

**Hoard's Survey of All Dairy Herds**

<http://ncdairyadvantage.com/ConferenceFeb2011/PresentationMikeHutjens/img49.html>

# **Animal Agriculture and our Food Supply**

**1. Does the worldwide supply of land limit food production?**

**Table 1. Land use: US and Worldwide**

<b>Land area and usage</b>	<b>World</b>	<b>US</b>	<b>US Share, %</b>
<b>Total land area, M km<sup>2</sup></b>	<b>149</b>	<b>9.1</b>	<b>6.1</b>
<b>Population, billion (2009)</b>	<b>6.78</b>	<b>0.31</b>	<b>4.5</b>
<b>Arable land, %</b>	<b>10.9</b>	<b>18.6</b>	<b>10.4</b>
<b>Permanent crops, %</b>	<b>1.04</b>	<b>0.21</b>	<b>1.2</b>
<b>Meadows, pastures, %</b>	<b>24.0</b>	<b>25.9</b>	<b>6.6</b>
<b>Forest, woodland, %</b>	<b>30.3</b>	<b>33.1</b>	<b>6.7</b>
<b>Irrigated, %</b>	<b>1.9</b>	<b>2.2</b>	<b>7.1</b>

*Grazing area = 50% of Land Area*

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*Crop byproducts*

*Grazing area = 3-5X Arable land*

# Common Byproduct Feeds

**Almond hulls**

**Beet pulp, wet & dried**

**Brewers grains, wet & dried**

**Citrus pulp**

**Corn gluten feed**

**Canola meal**

**Citrus pulp**

**Cottonseed**

**Distillers grains**

**Hominy feed**

**Molasses, cane & beet**

**Rice bran**

**Safflower meal**

**Soy hulls**

**Wheat mill run**

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***“Variability in nutrient content (and high fiber content) limits the value and use of byproduct feeds.”***

# Commercial Diet Types

High fiber

*Diet type*

Concentrate

Forages

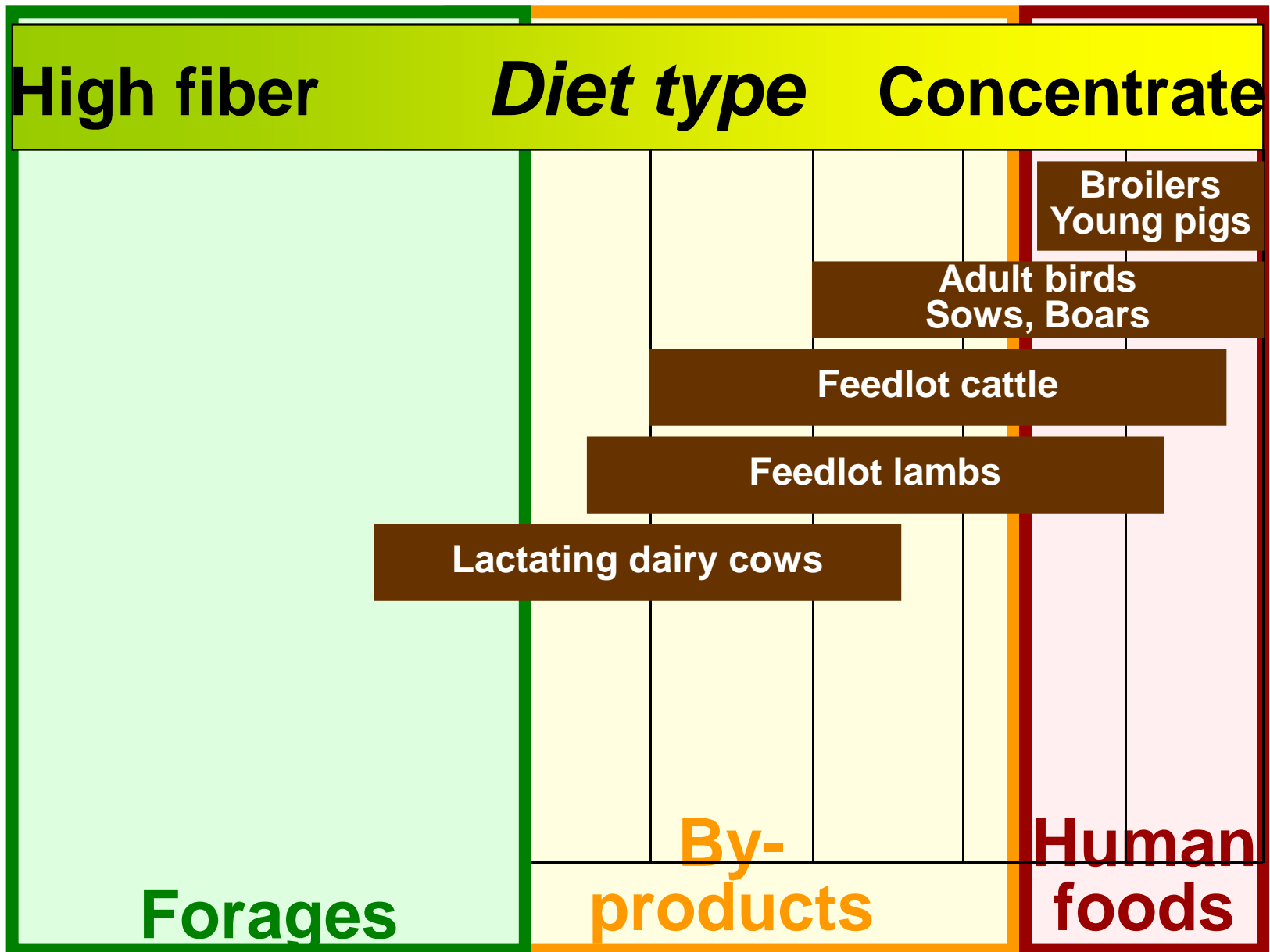
By-  
products

Human  
foods

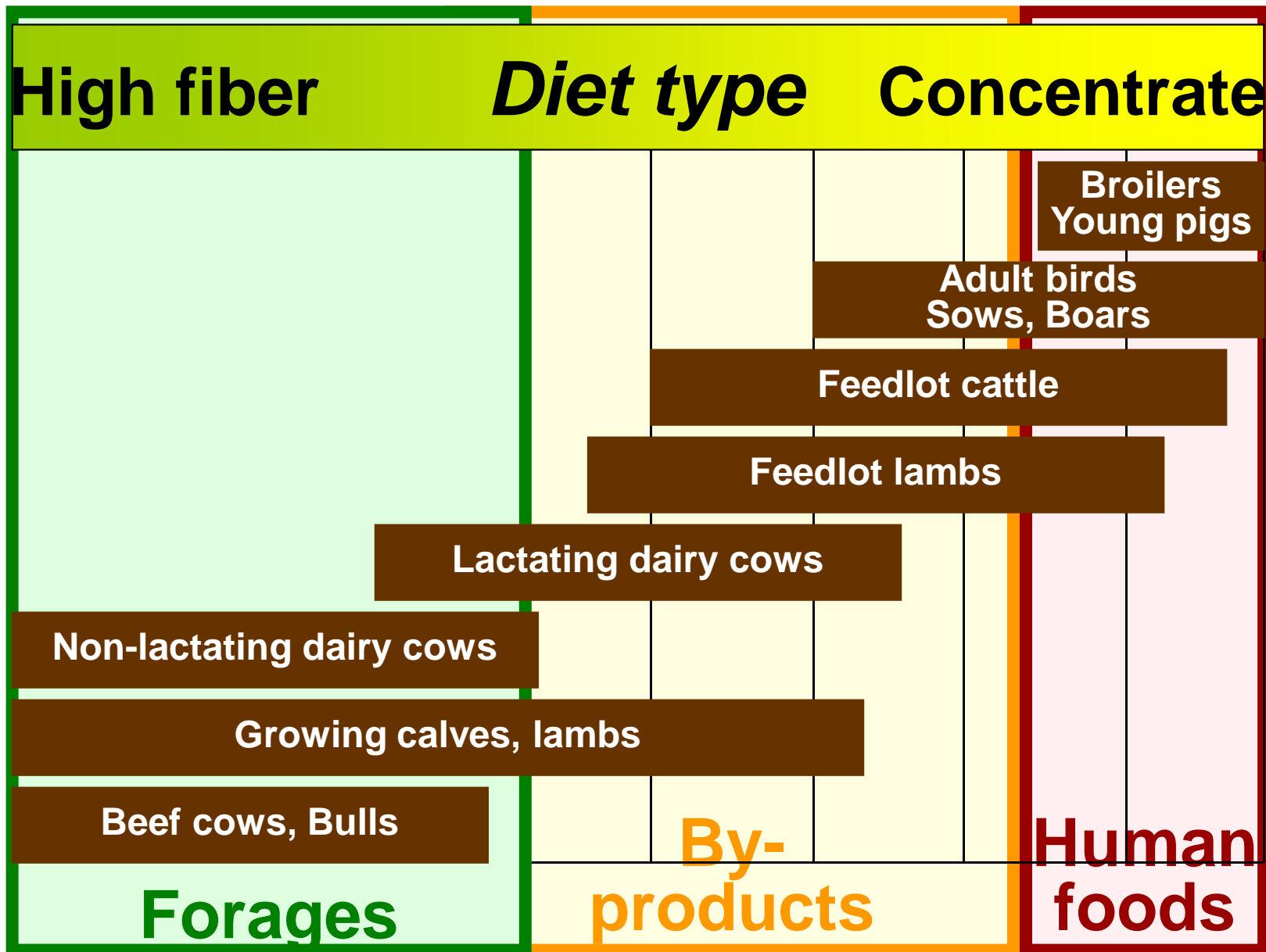
# Commercial Diet Types - US

High fiber	<i>Diet type</i>		Concentrate	
Forages		By-products		Broilers Young pigs
			Adult birds Sows, Boars	
				Human foods

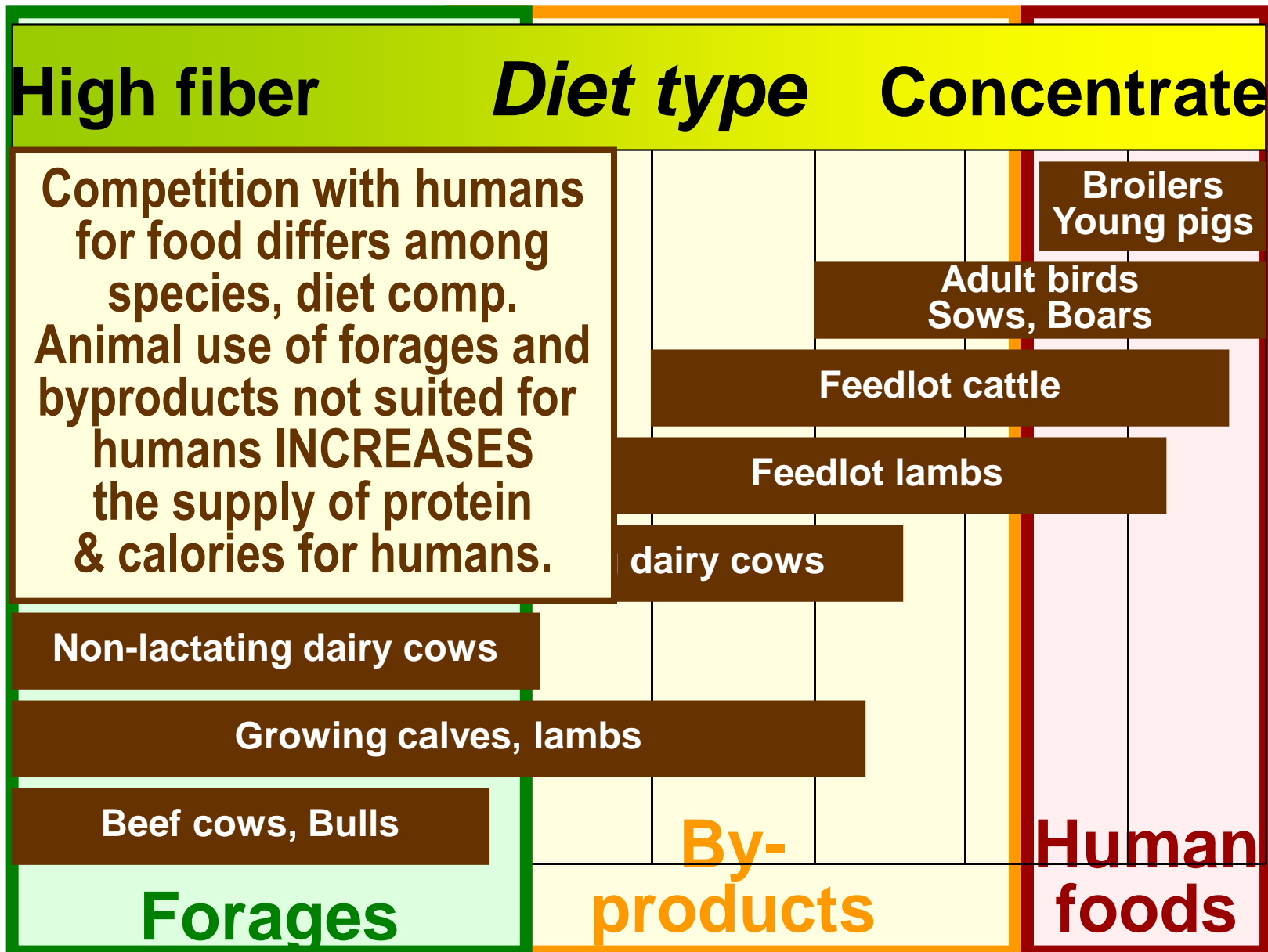
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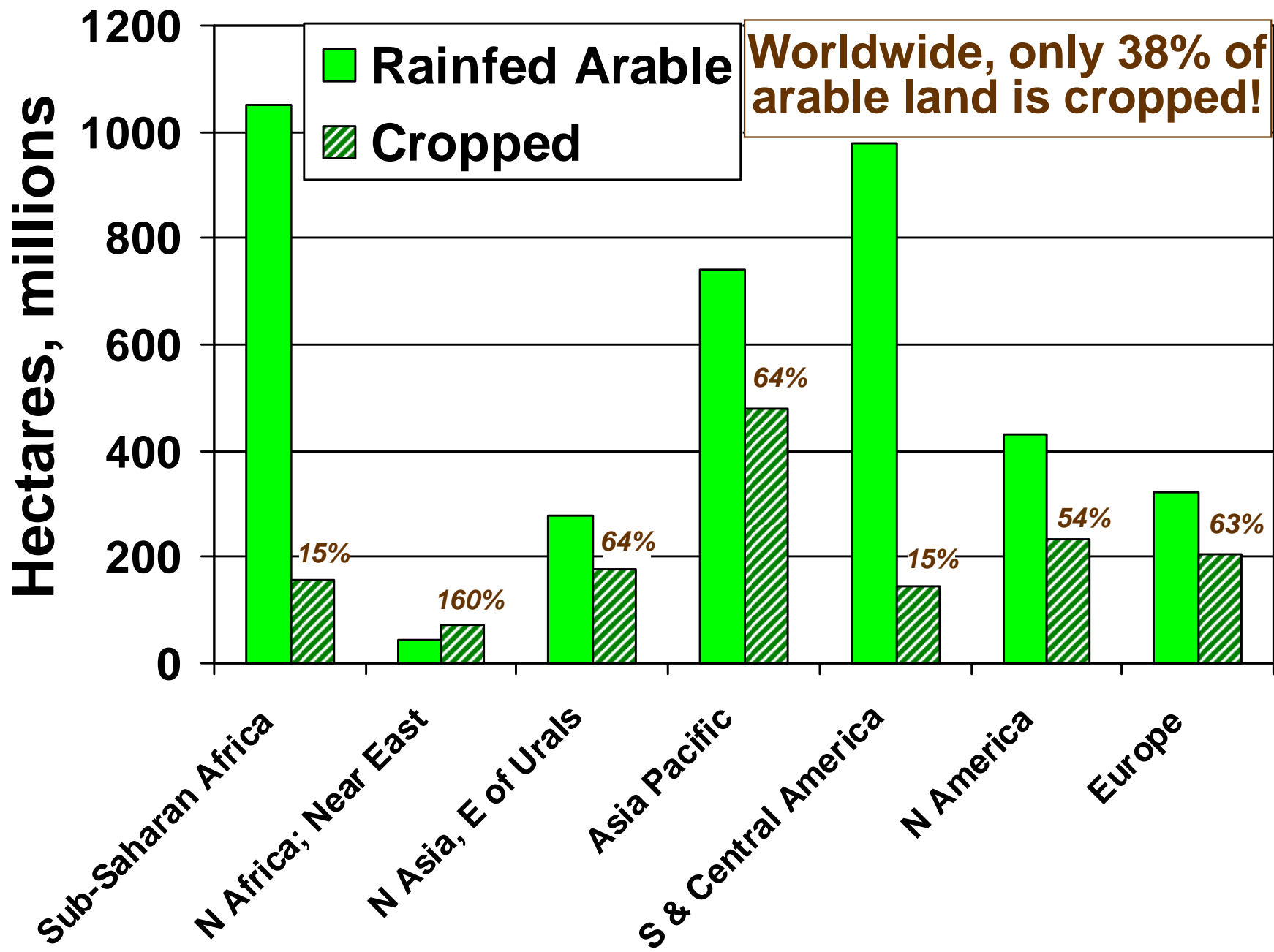


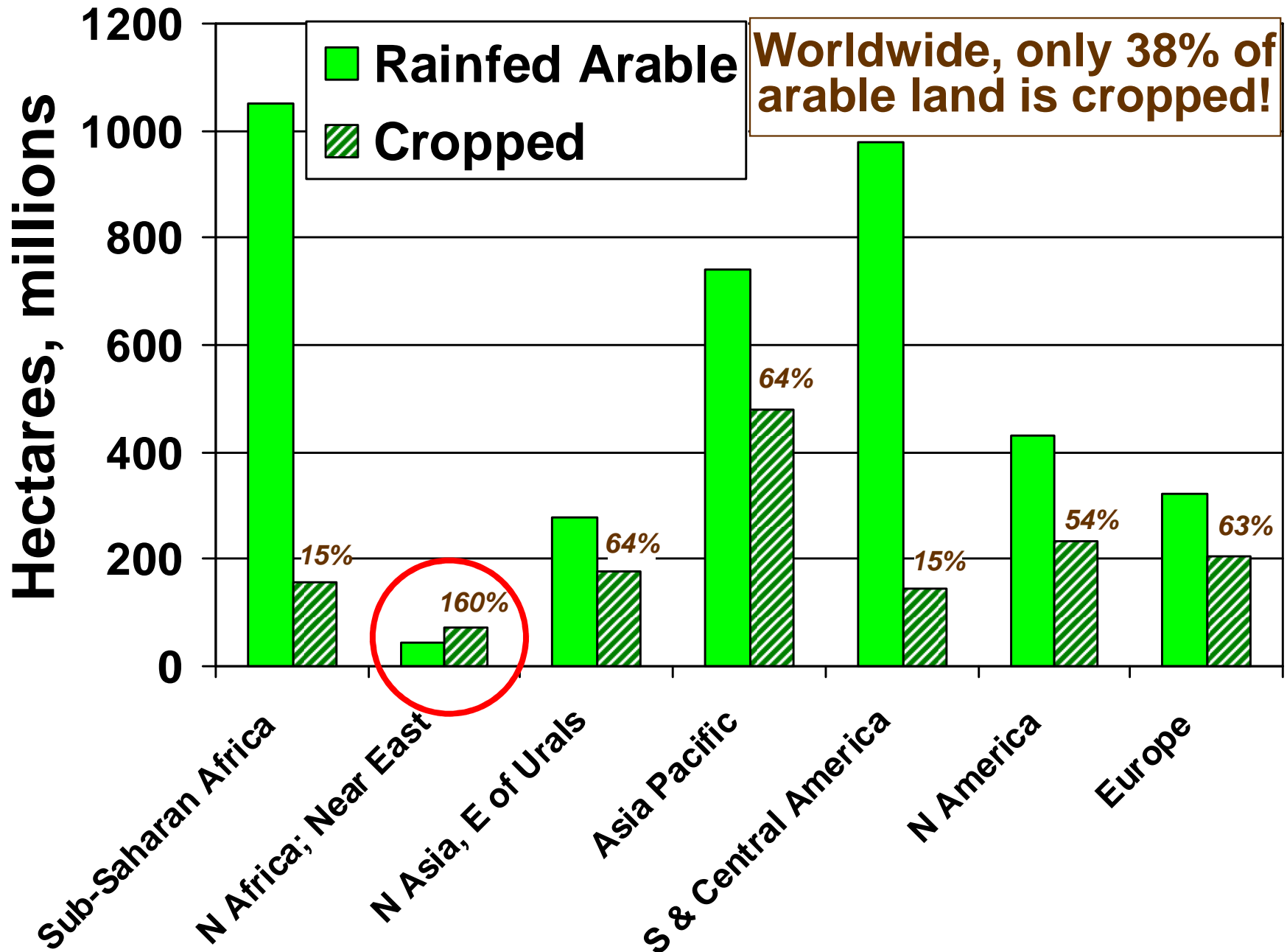
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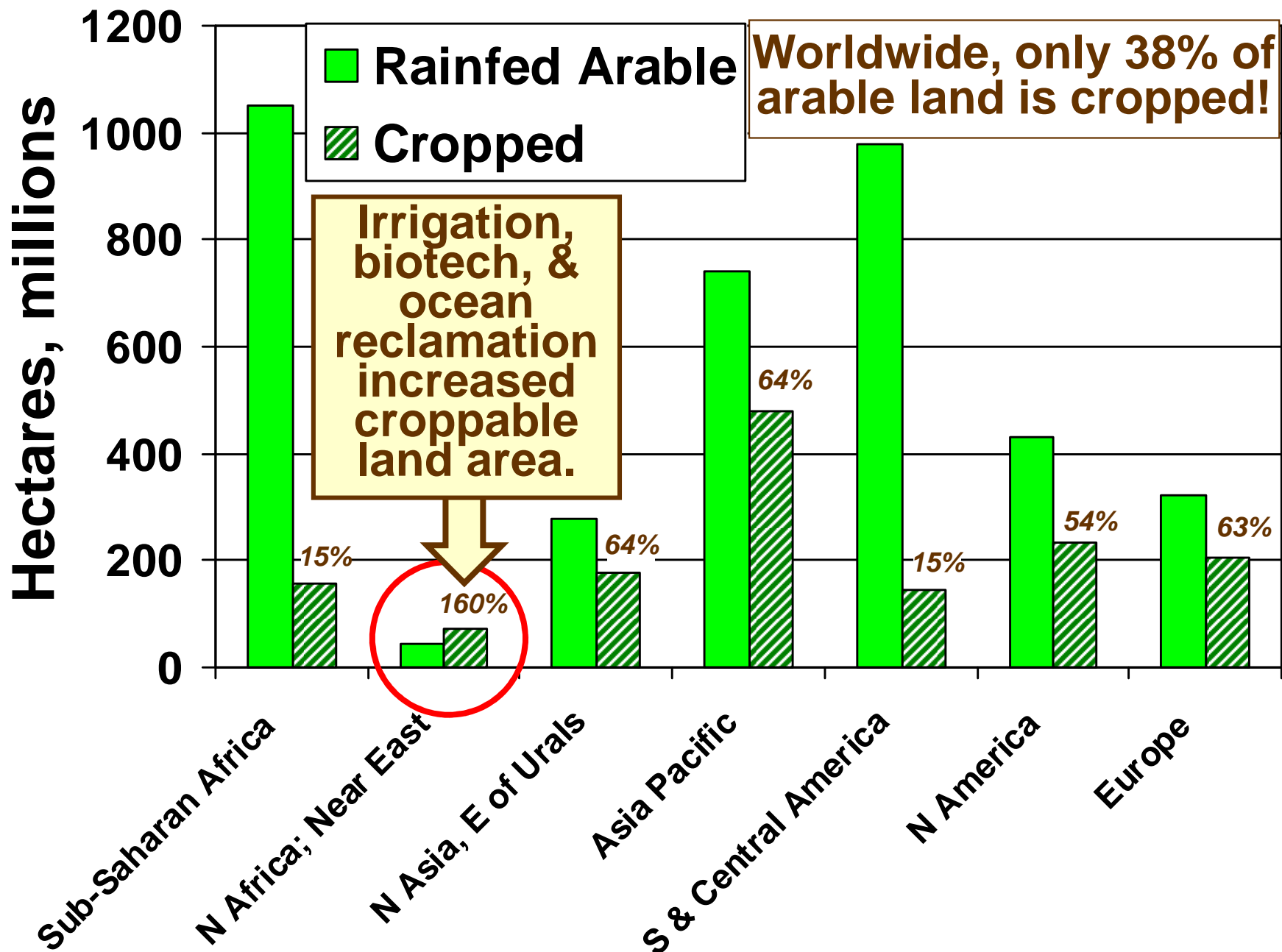


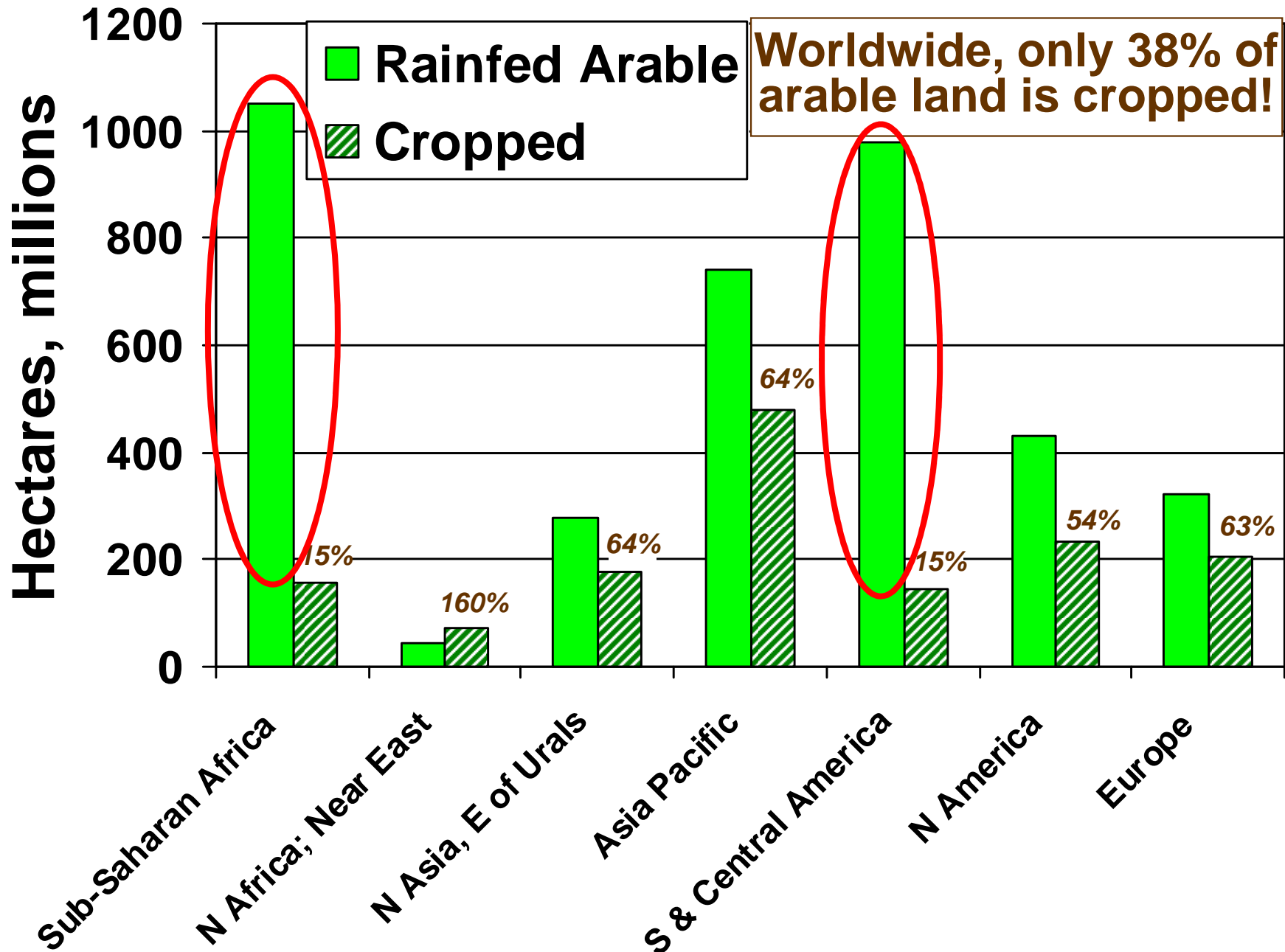
## Animal Agriculture and our Food Supply

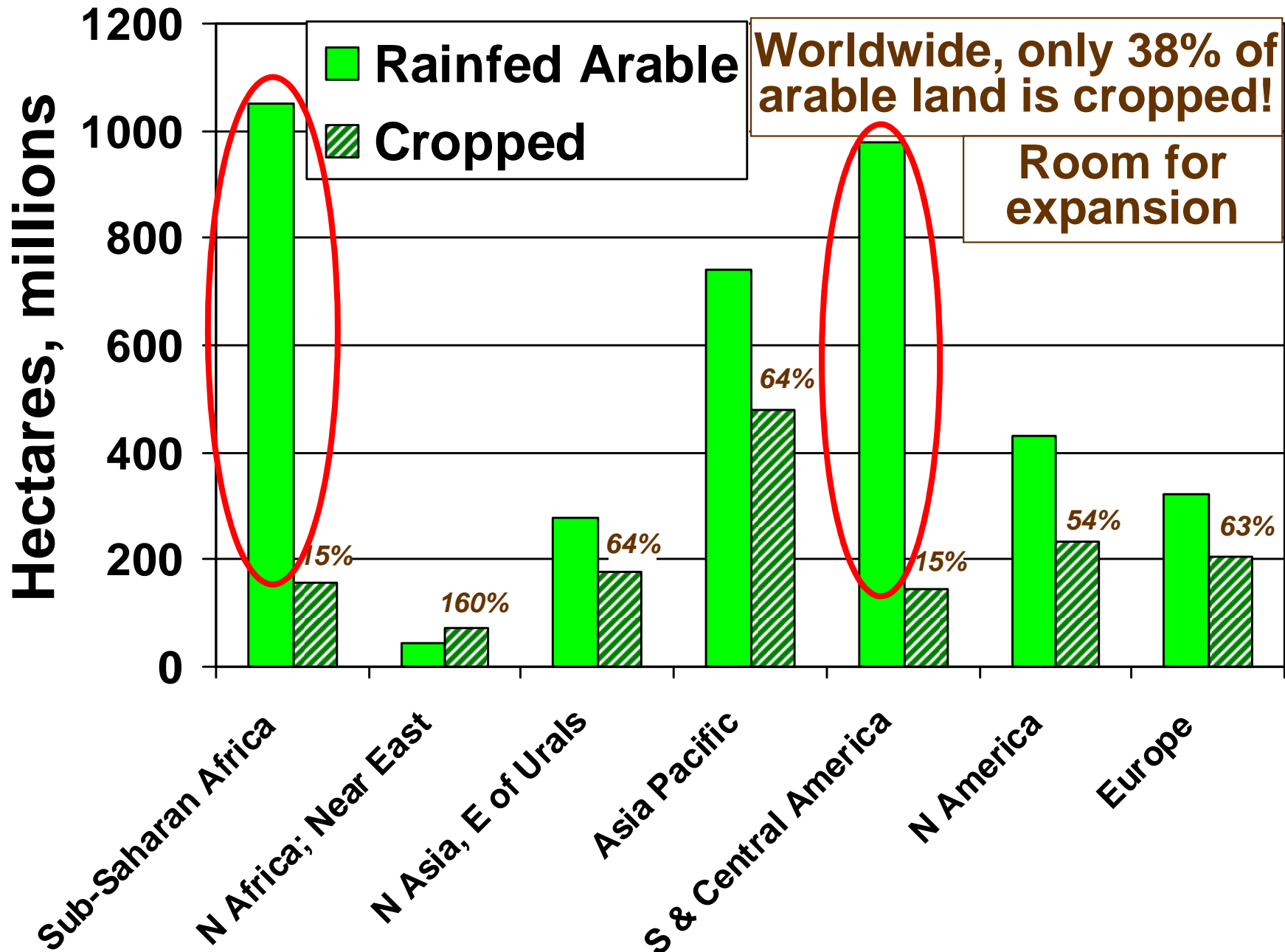
2. Does the worldwide supply of **arable** land (*rain-fed area suited for crop production*) limit food production?











# Balance of Energy & Nutrients

## Supply

Pasture or Crop Land

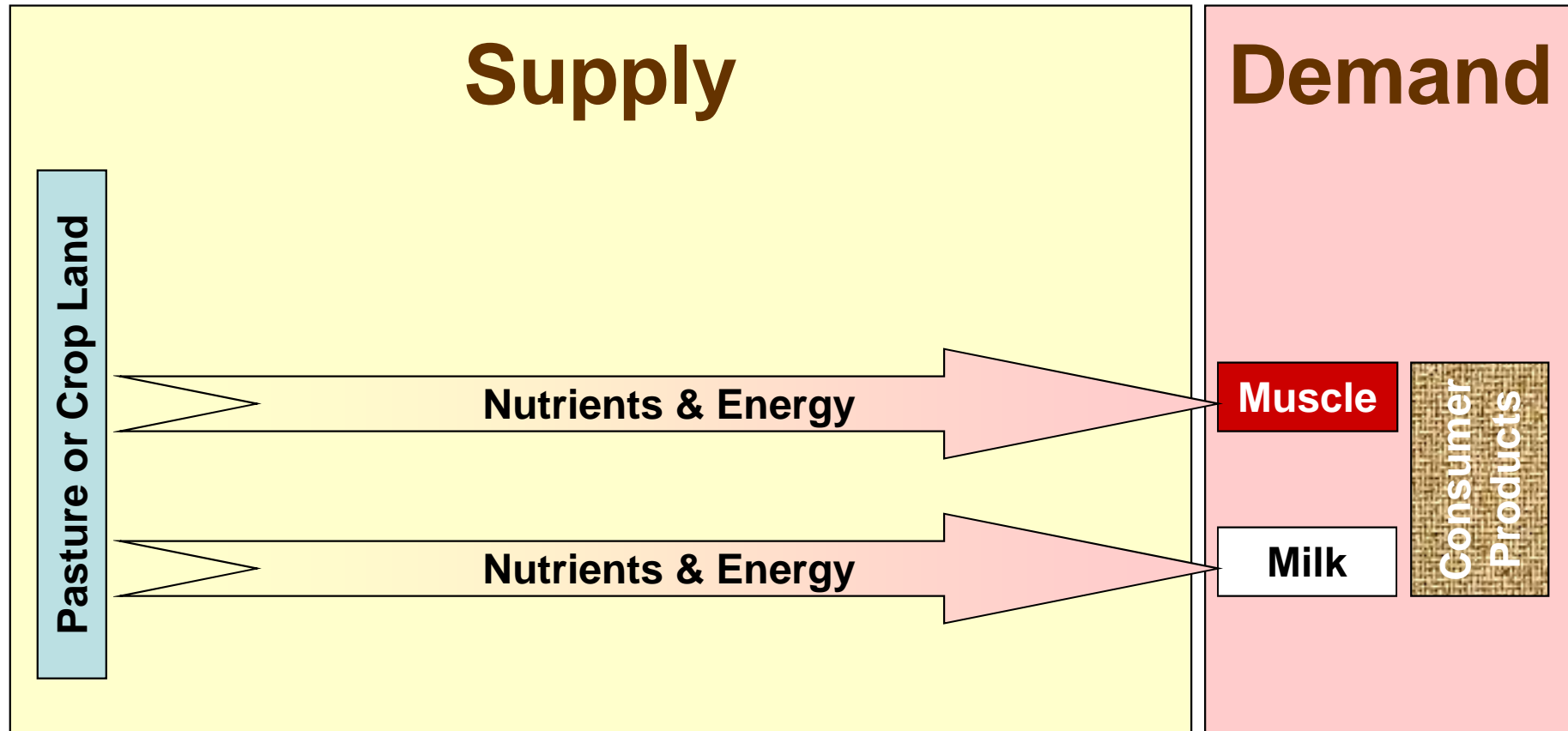
## Demand

Muscle

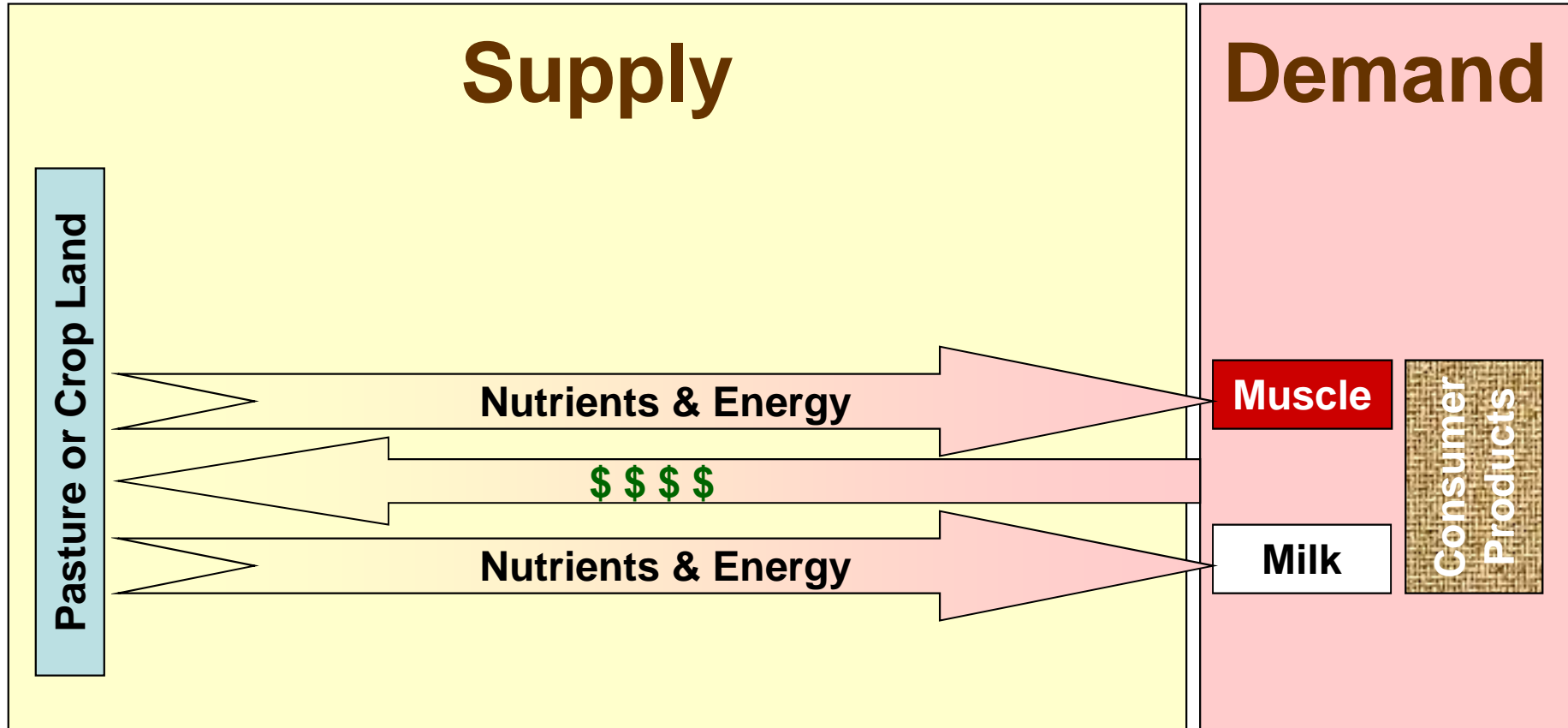
Milk

Consumer  
Products

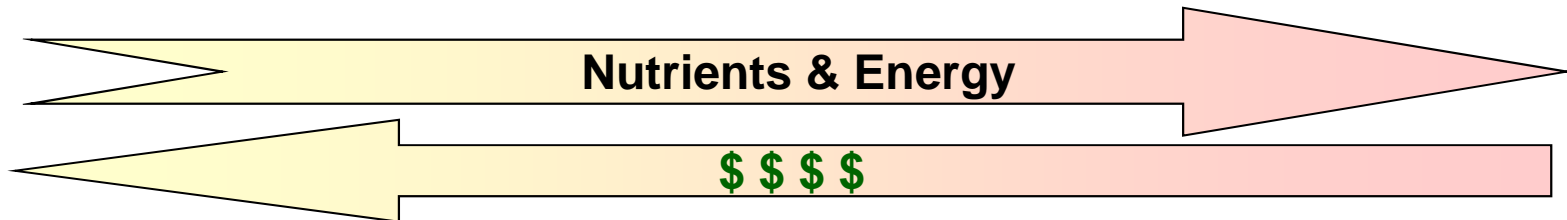
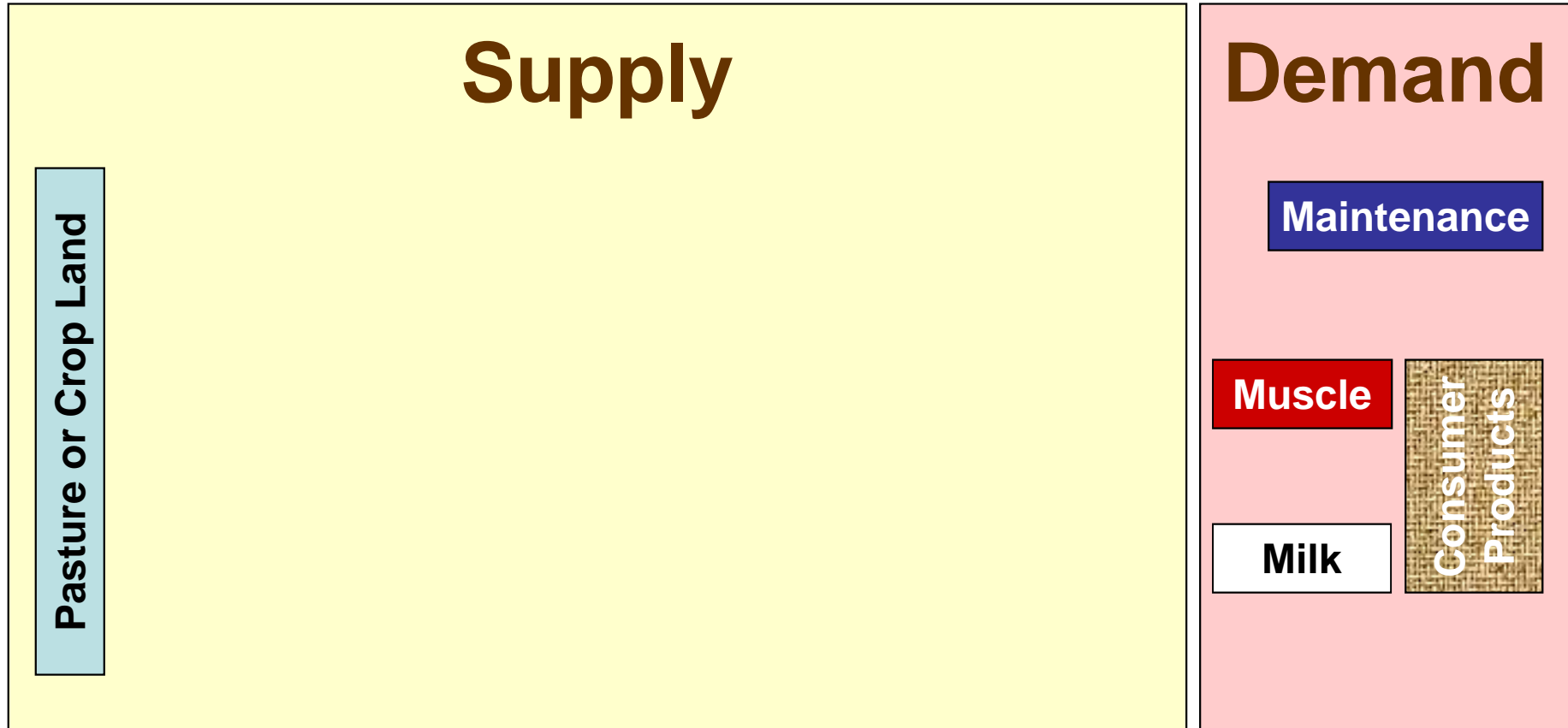
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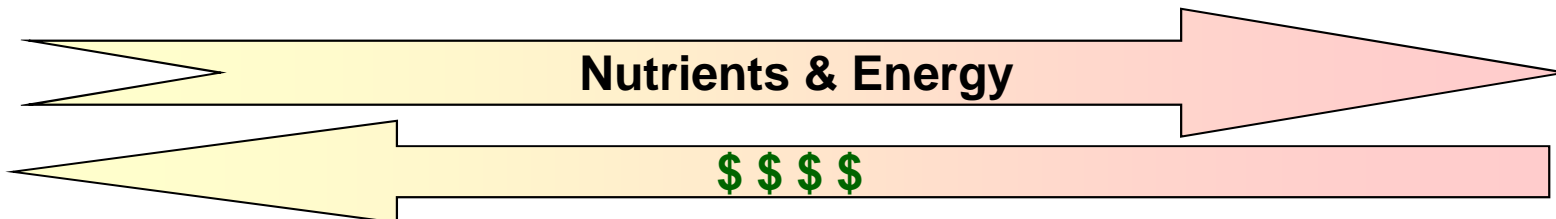
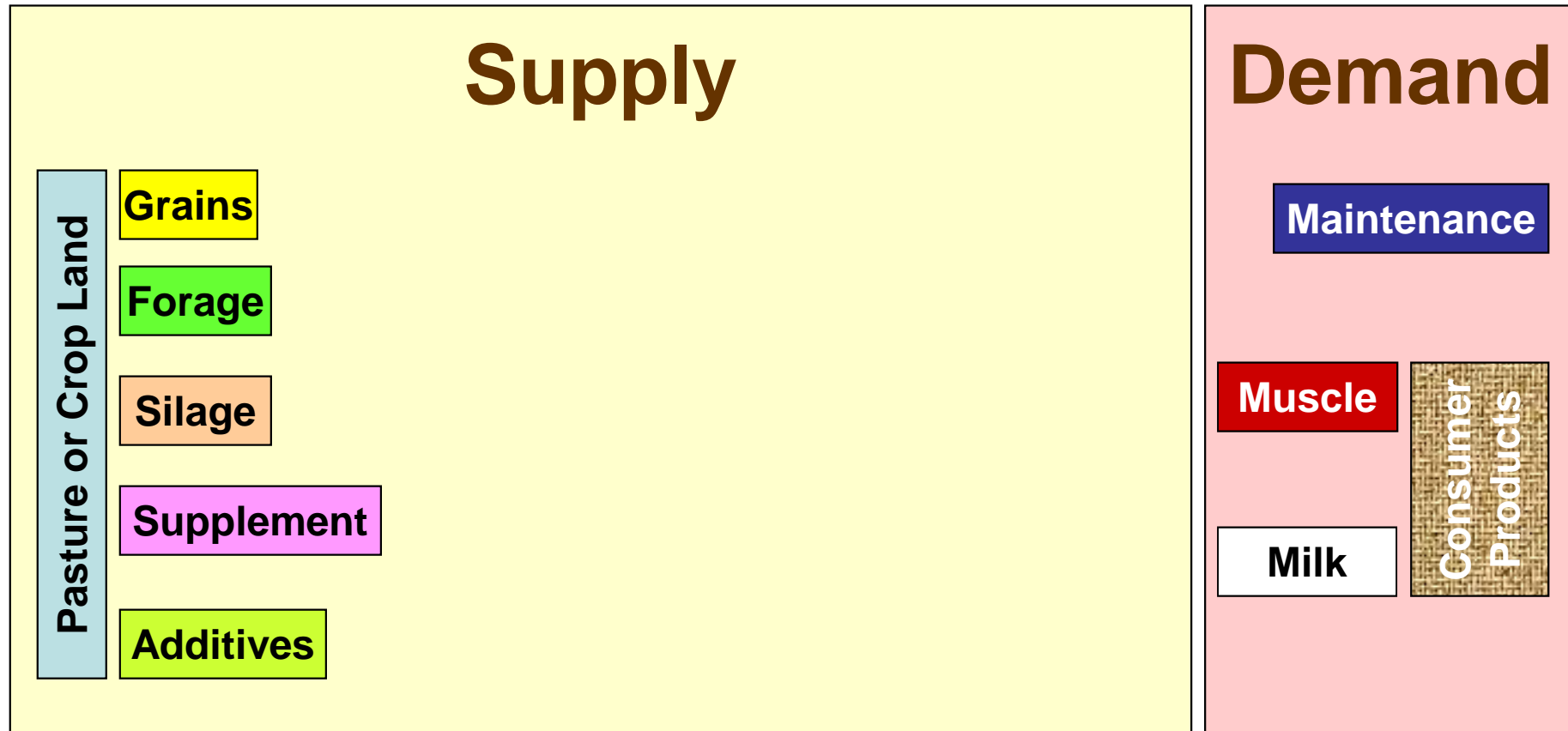
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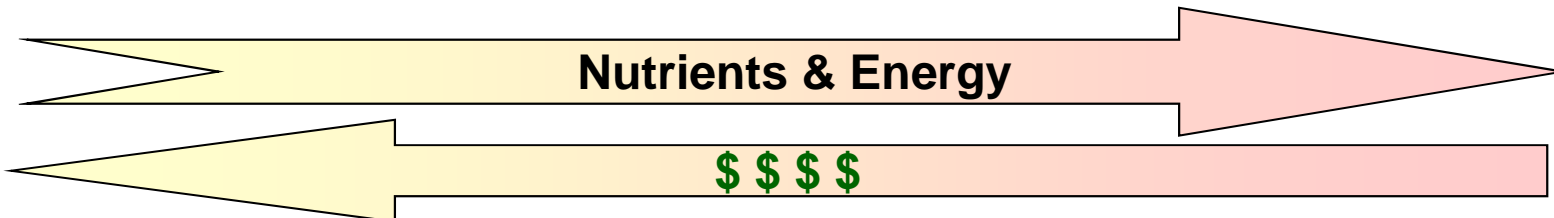
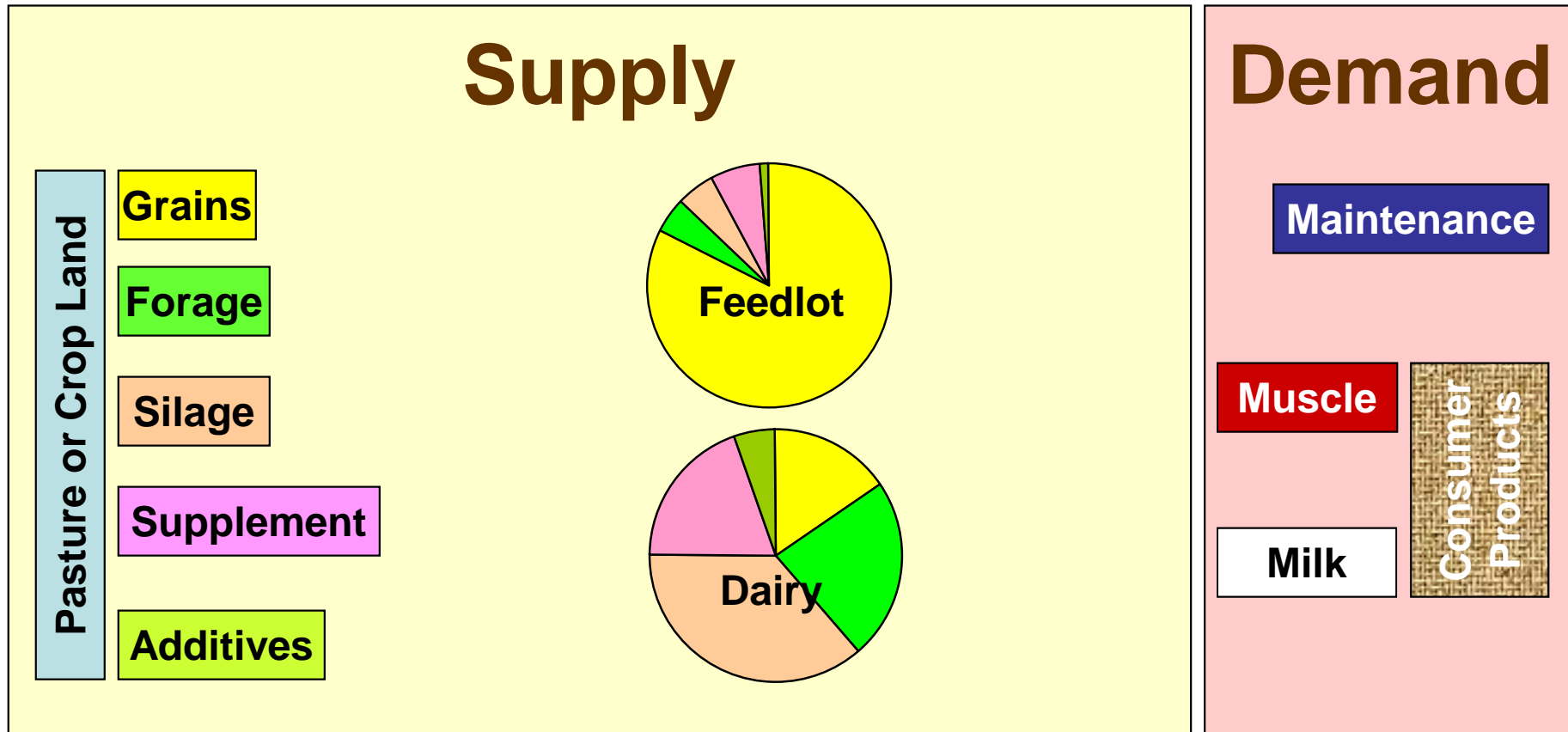
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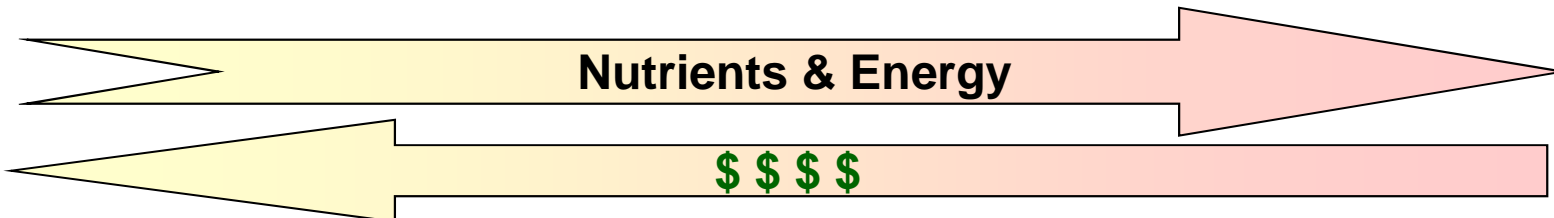
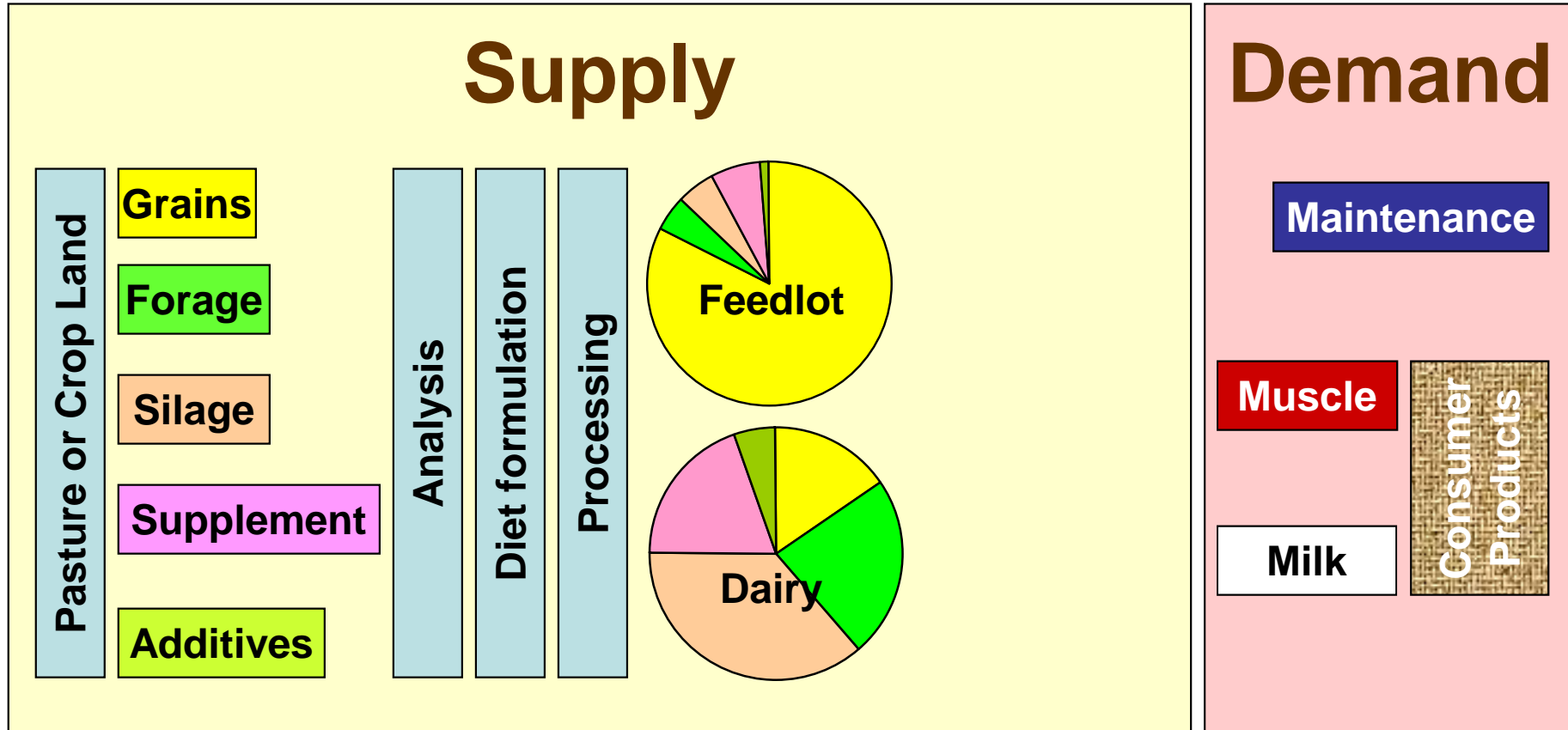
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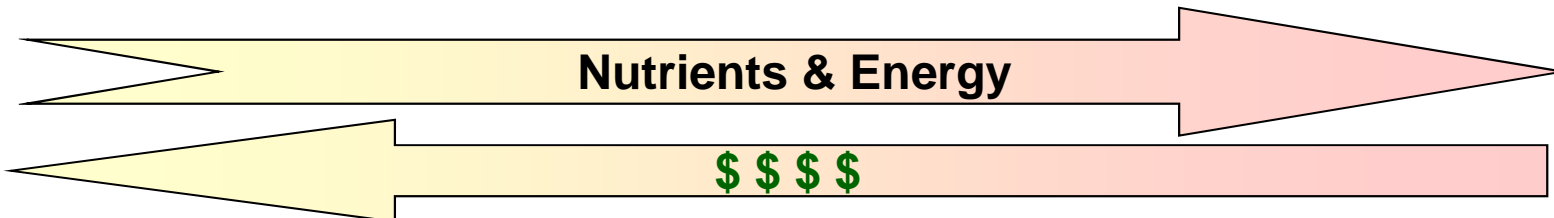
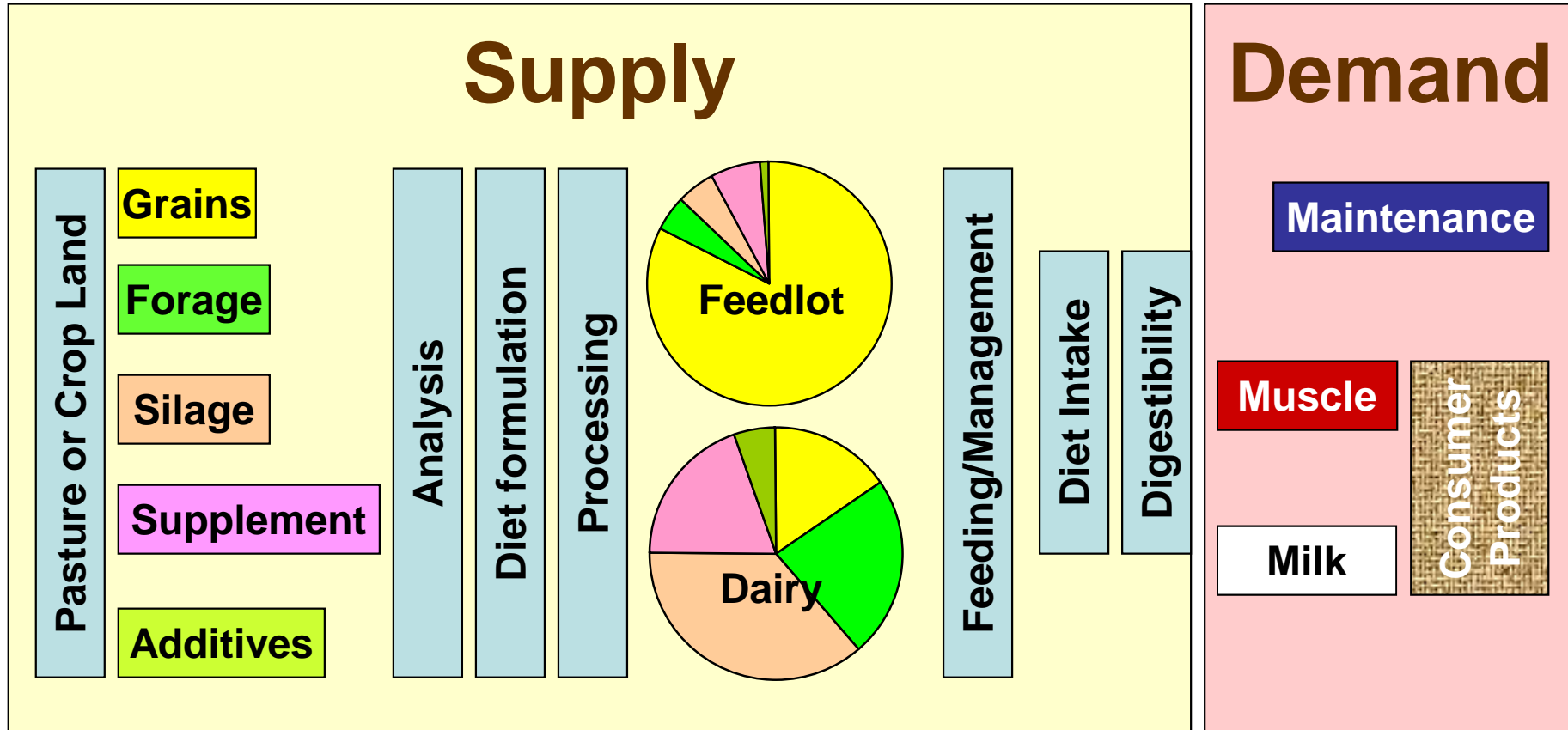
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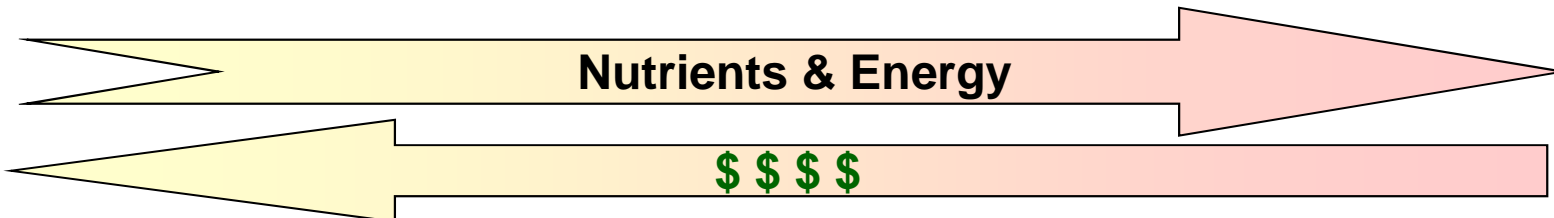
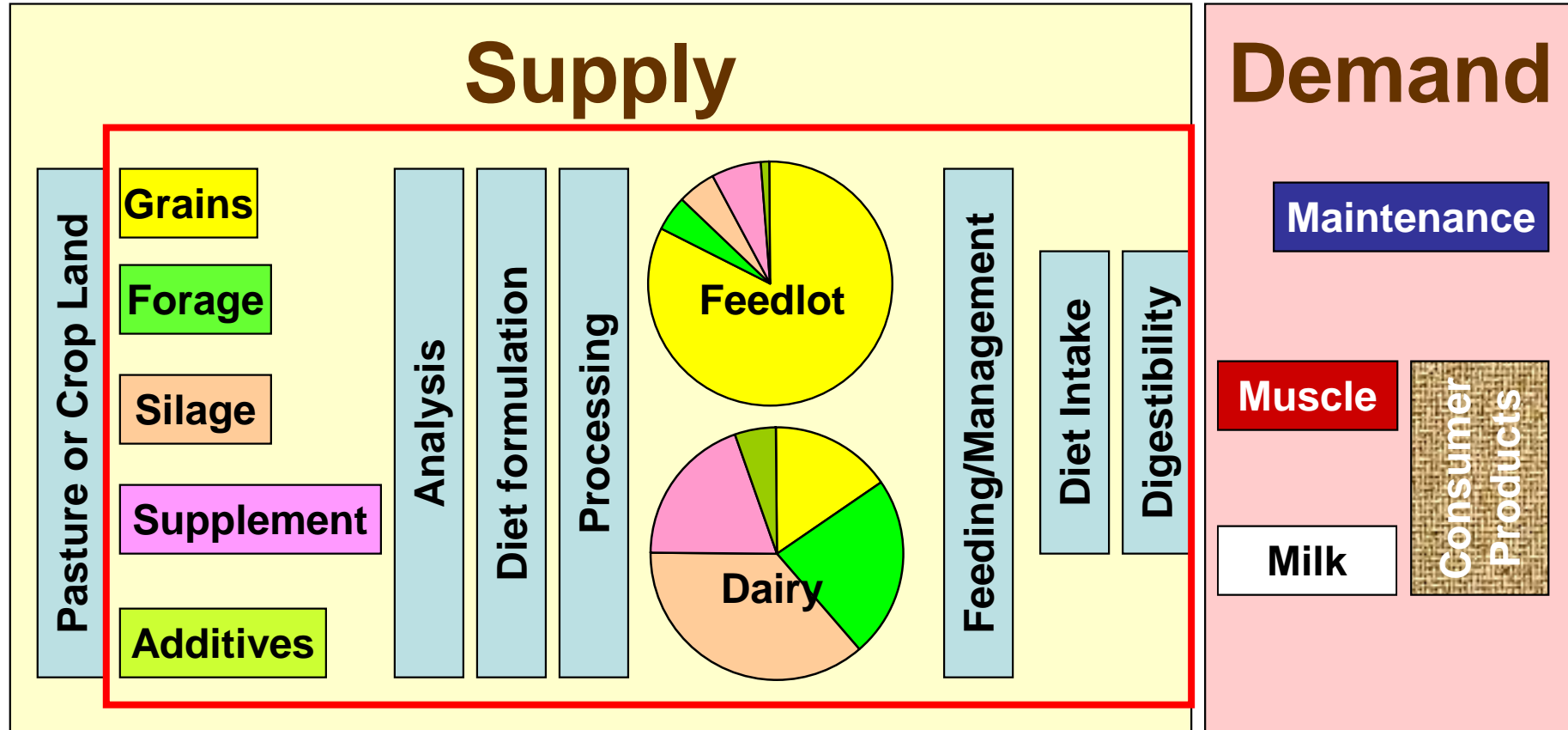
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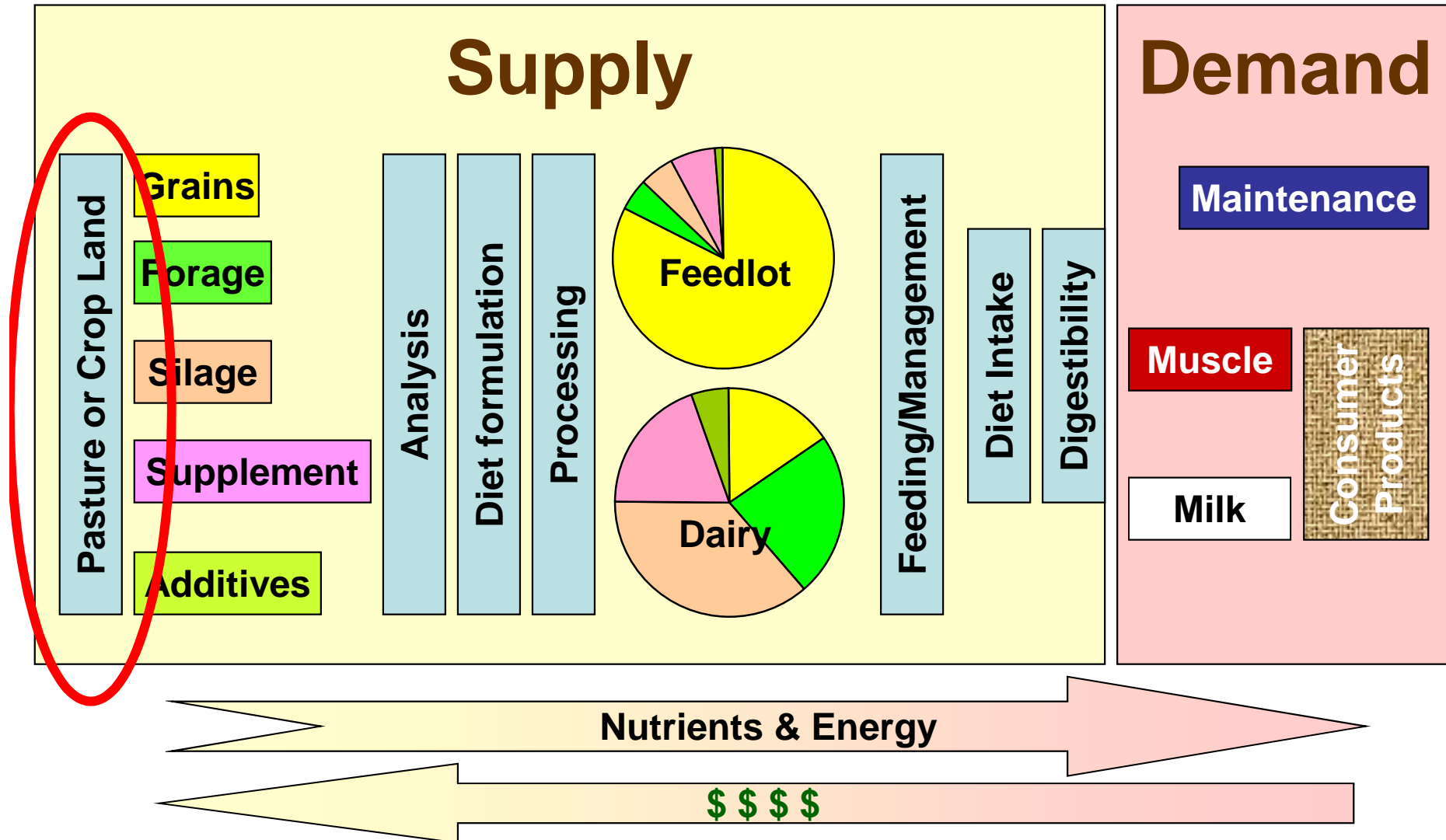
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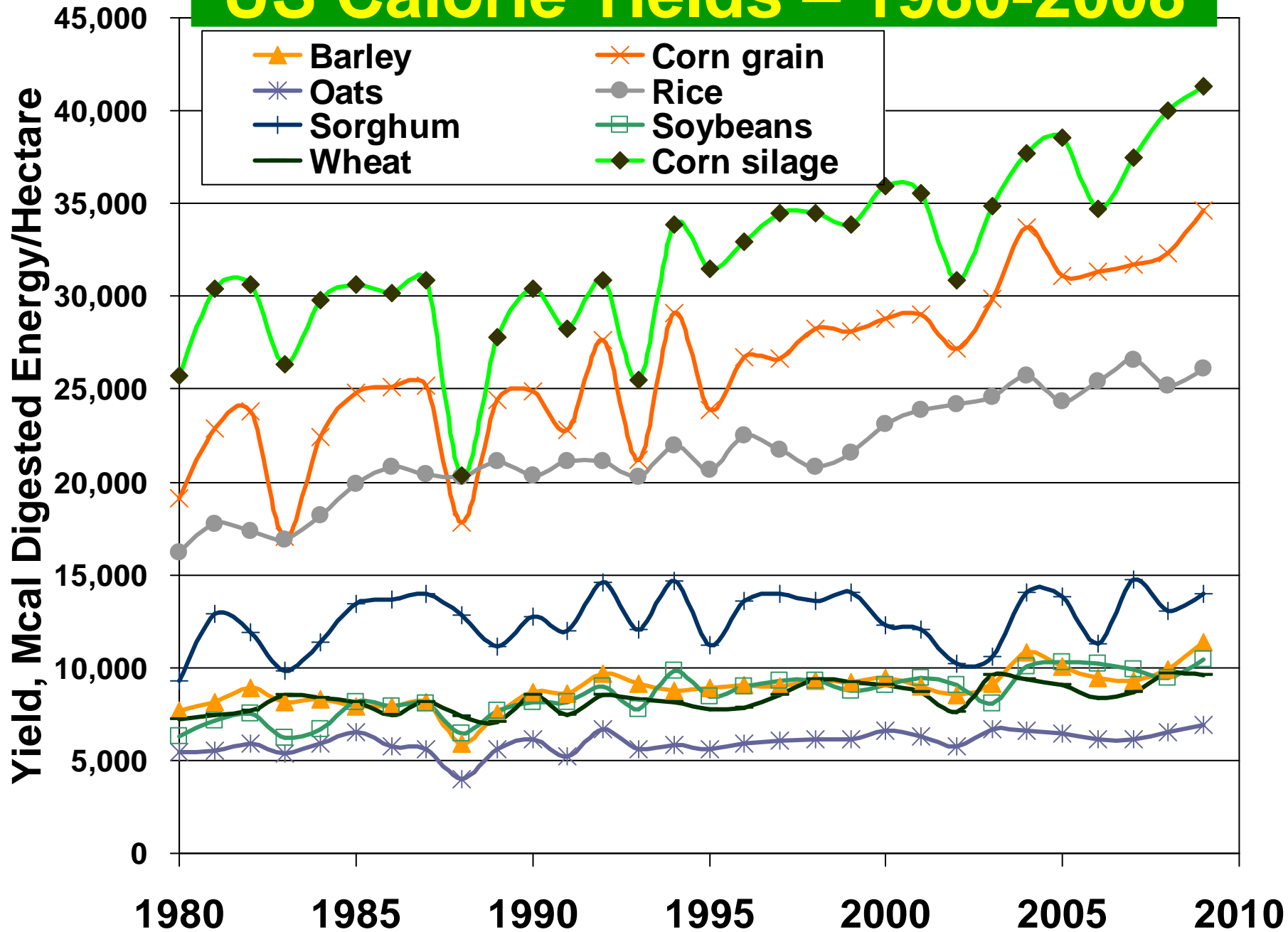
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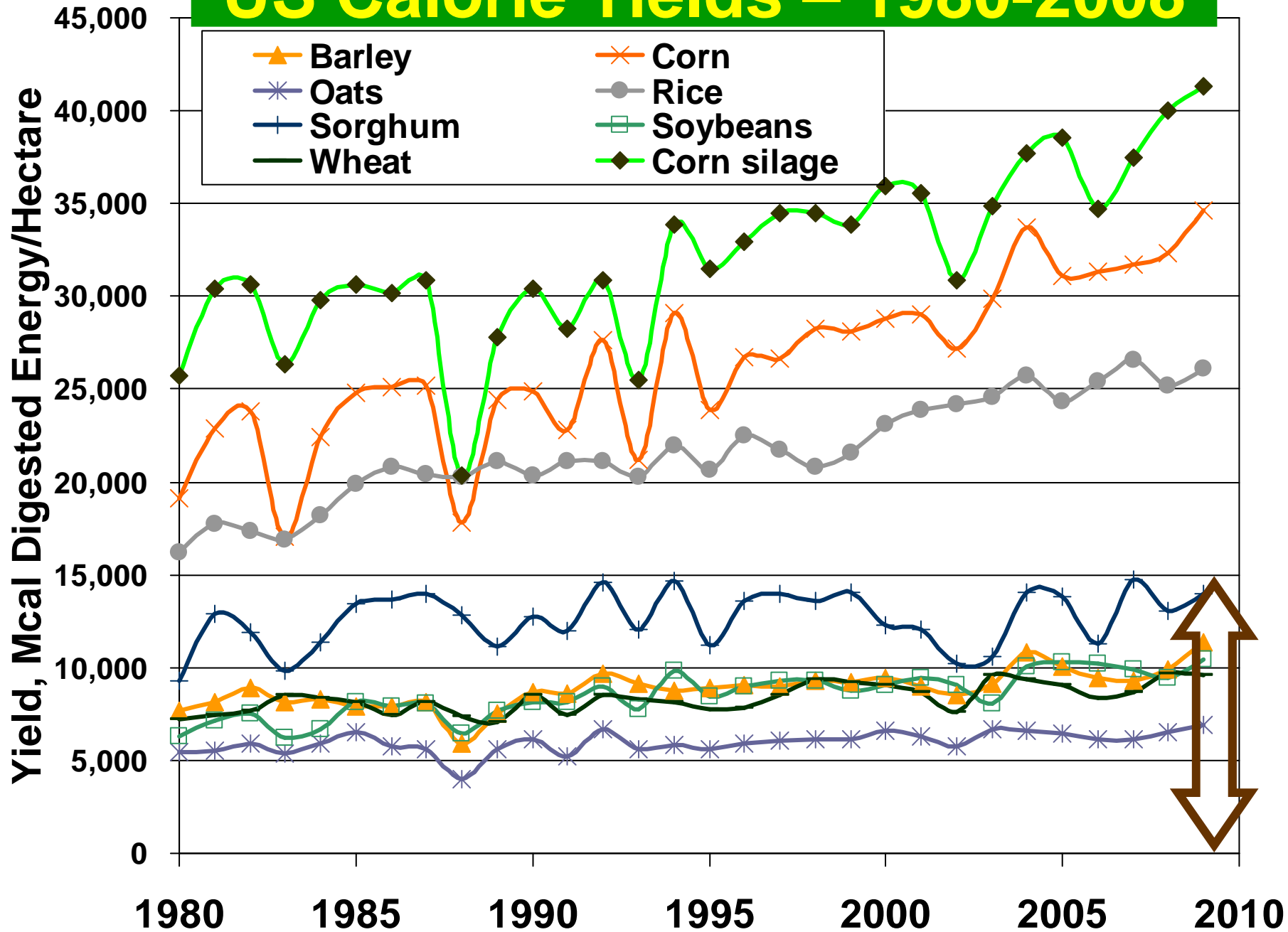
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- 6. Yield – Silage vs ears vs grain alone.**

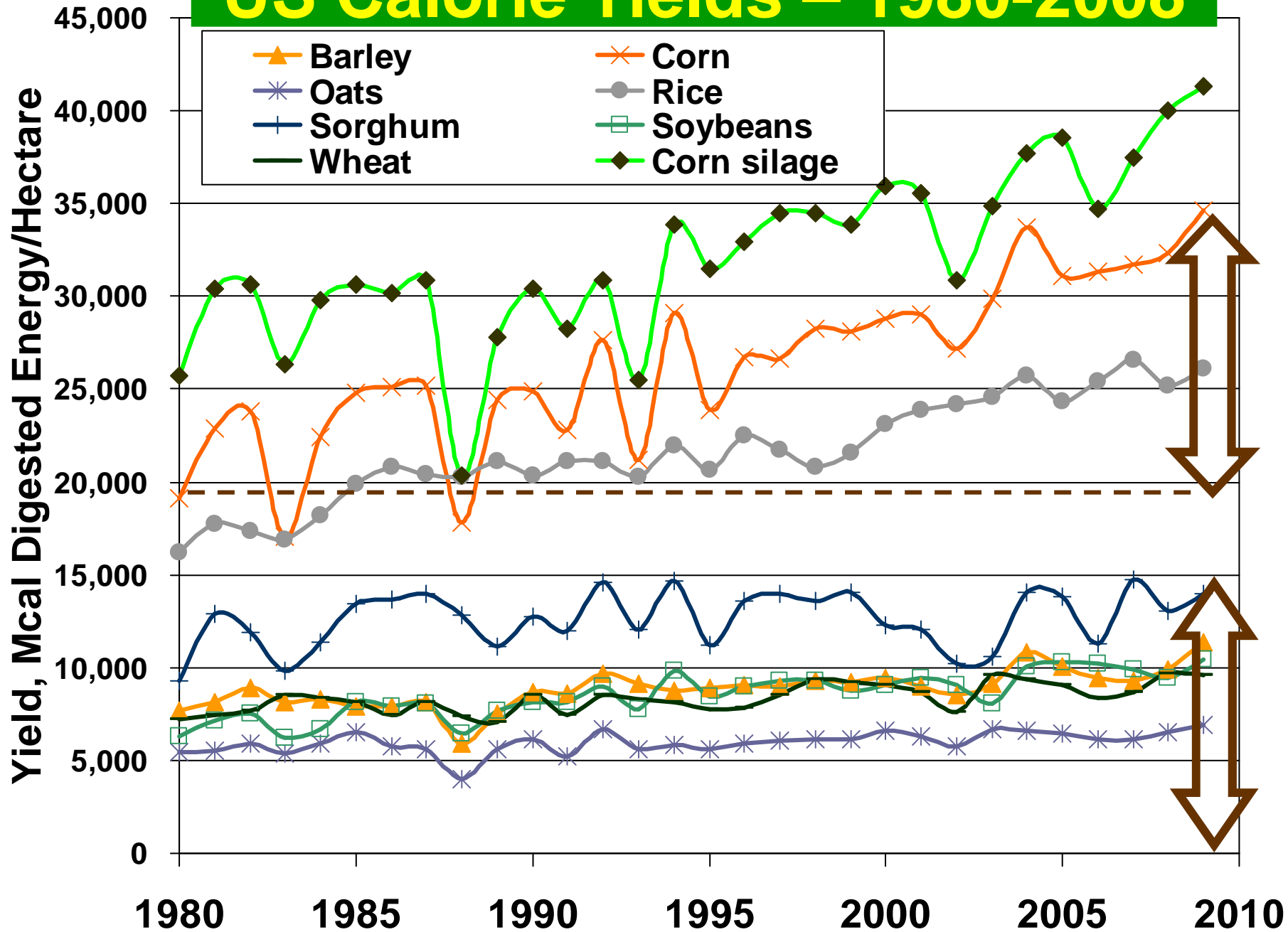
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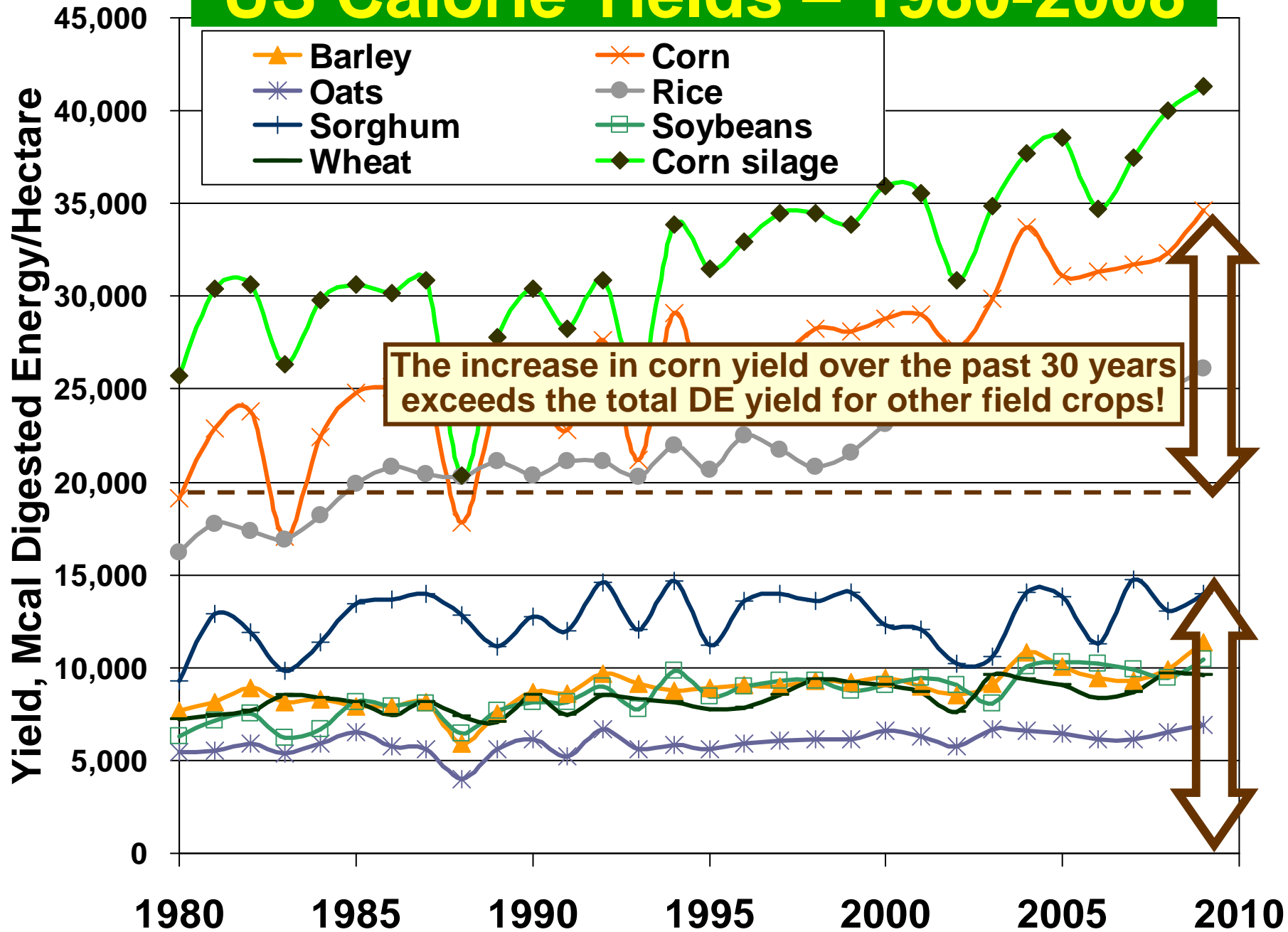
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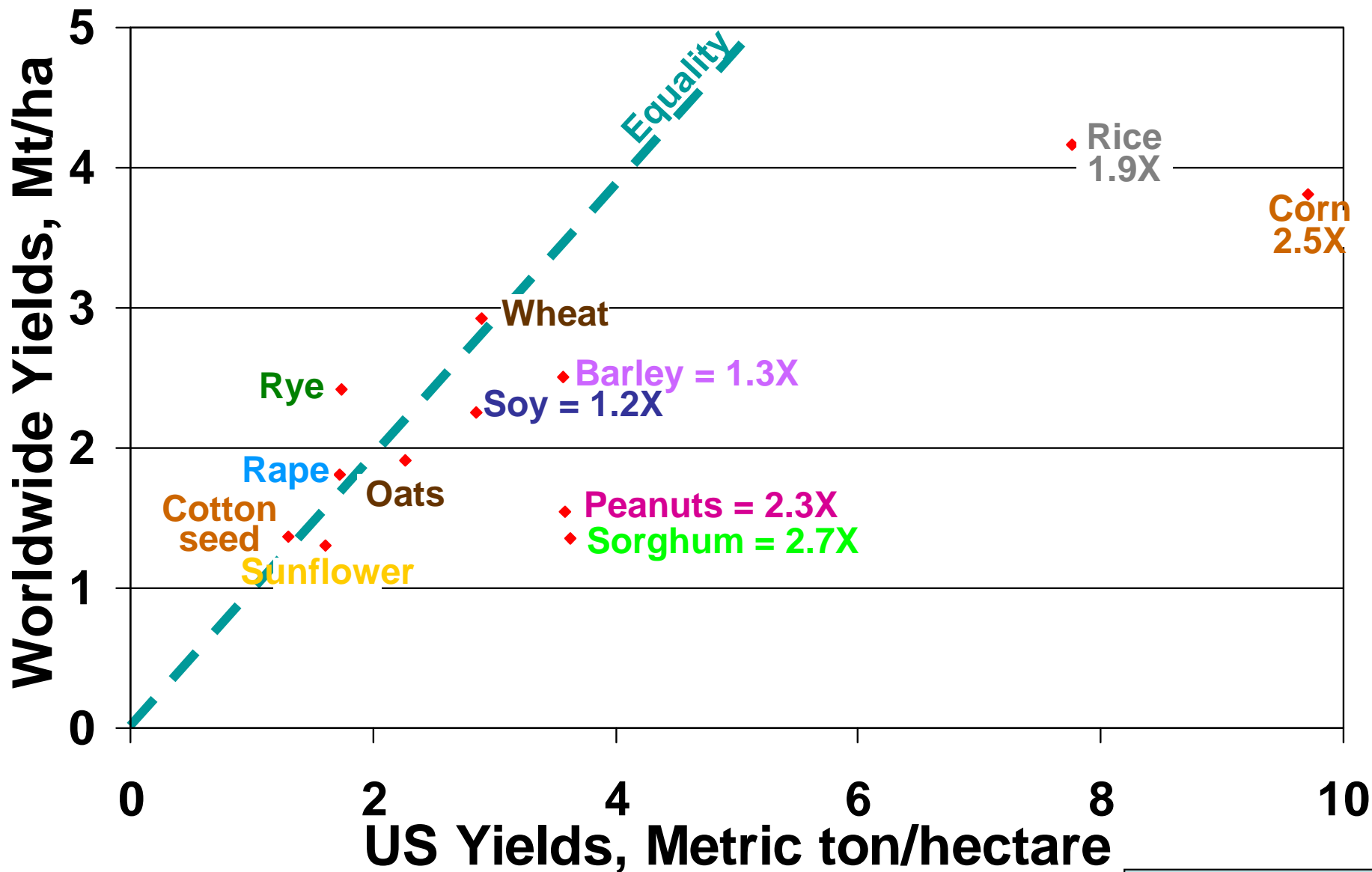
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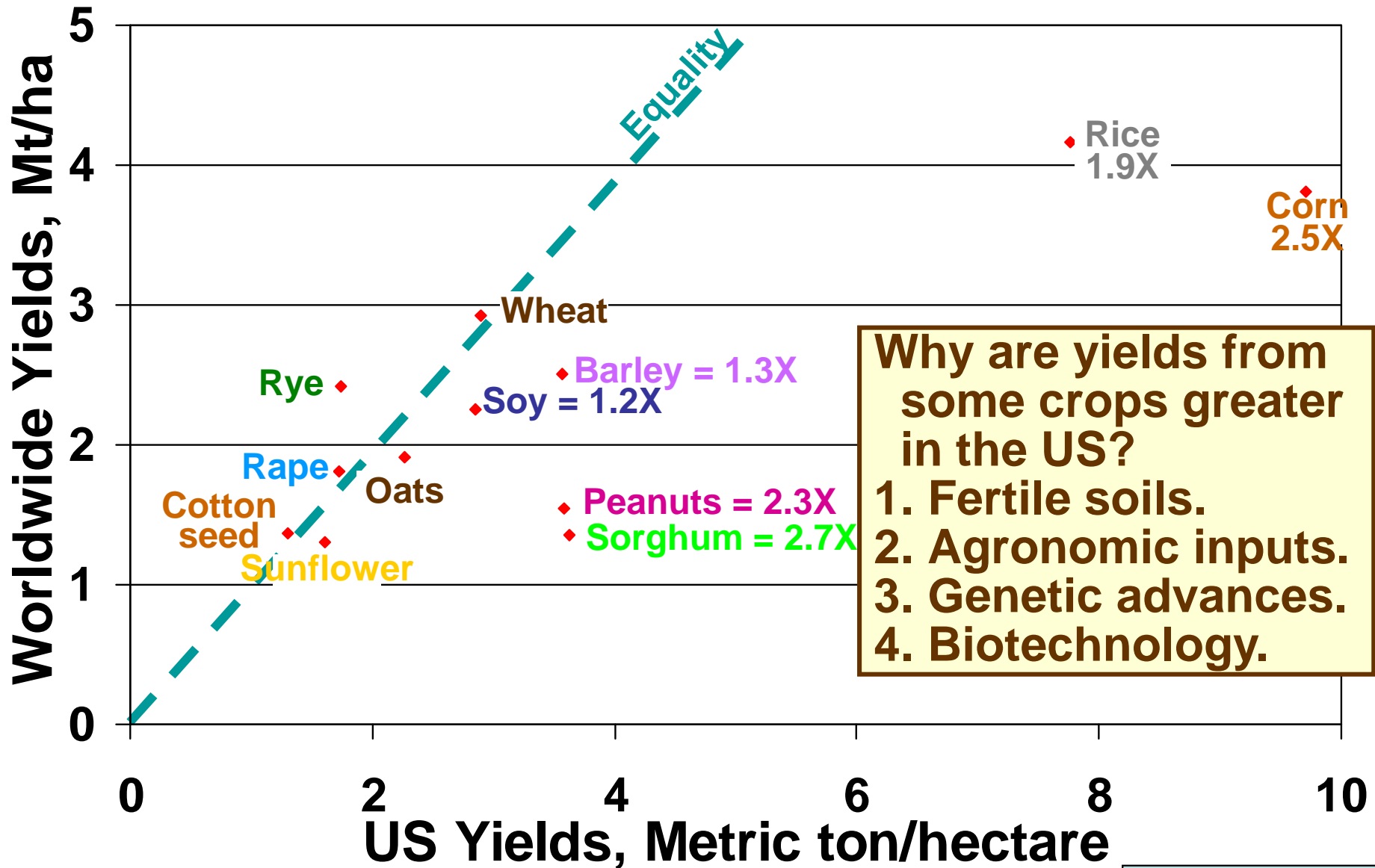
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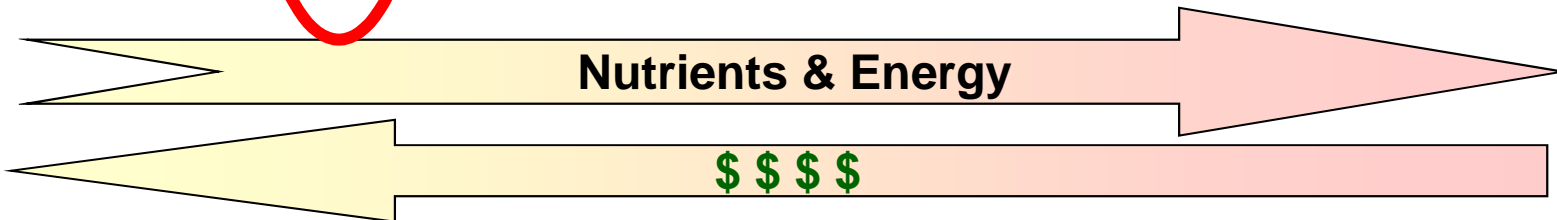
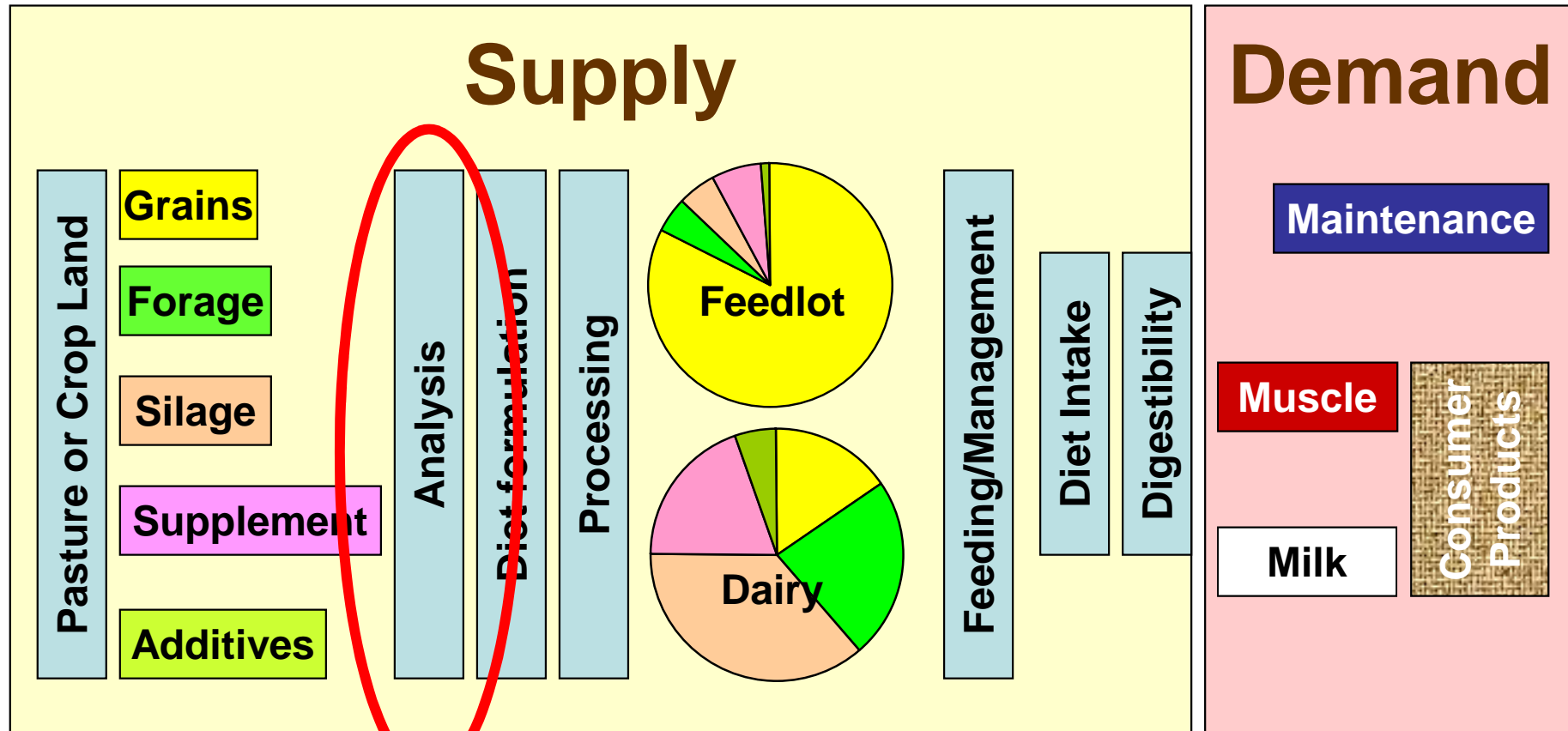
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**Why are yields from some crops greater in the US?**

1. Fertile soils.
2. Agronomic inputs.
3. Genetic advances.
4. Biotechnology.

# Balance of Energy & Nutrients

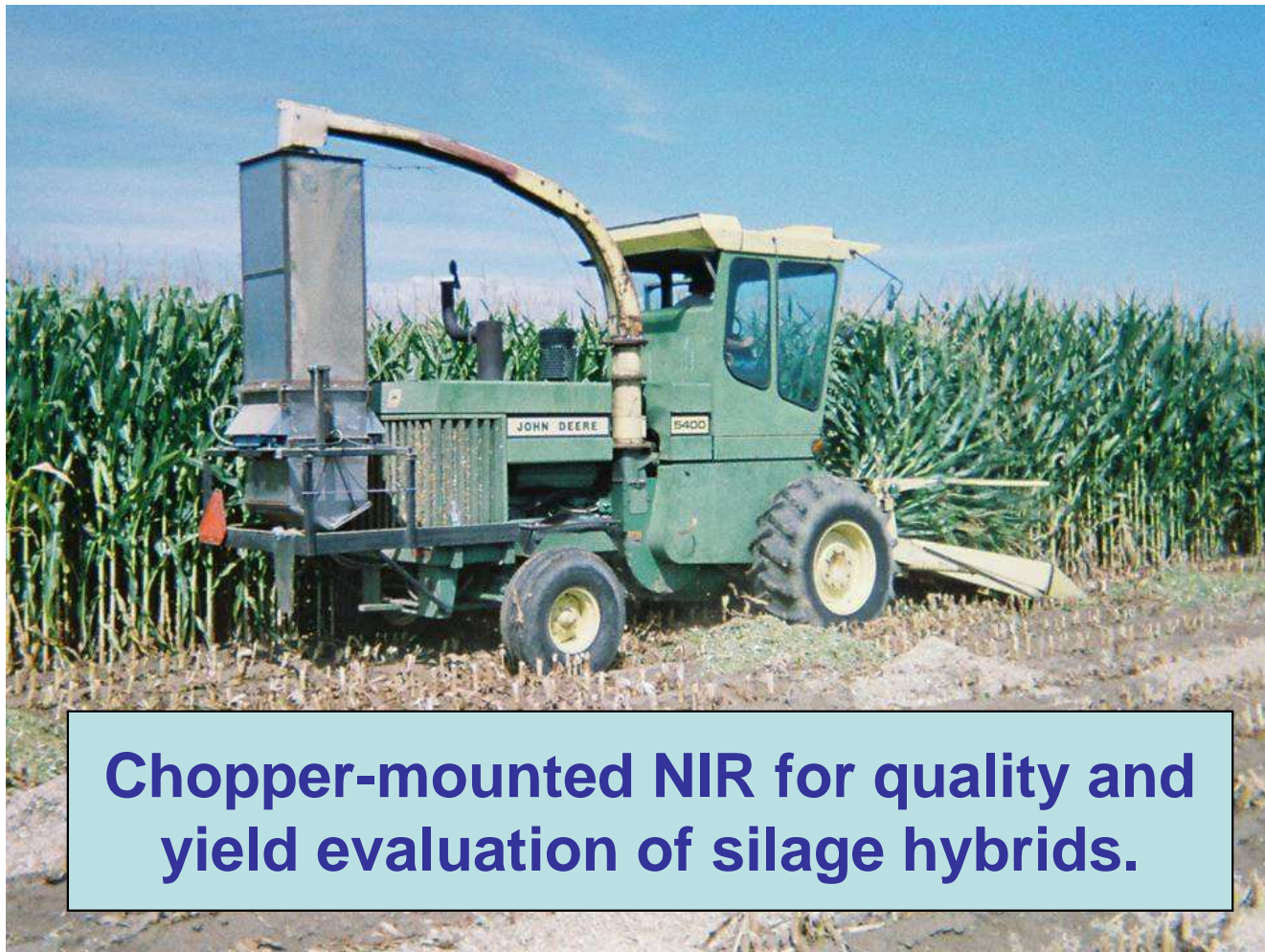


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- 1. Rapid nutrient analysis – Near-Infrared reflectance/transmission.**

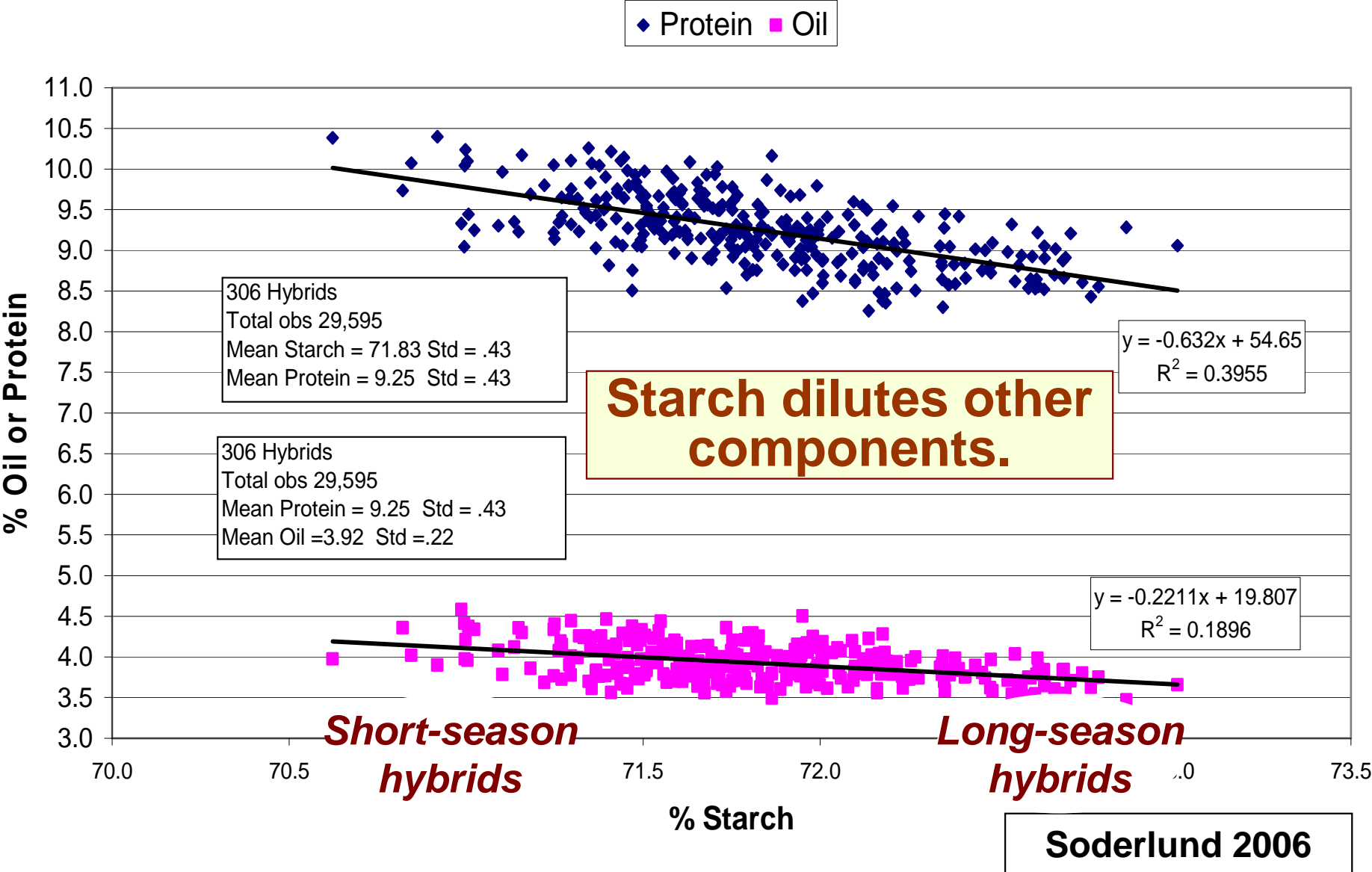
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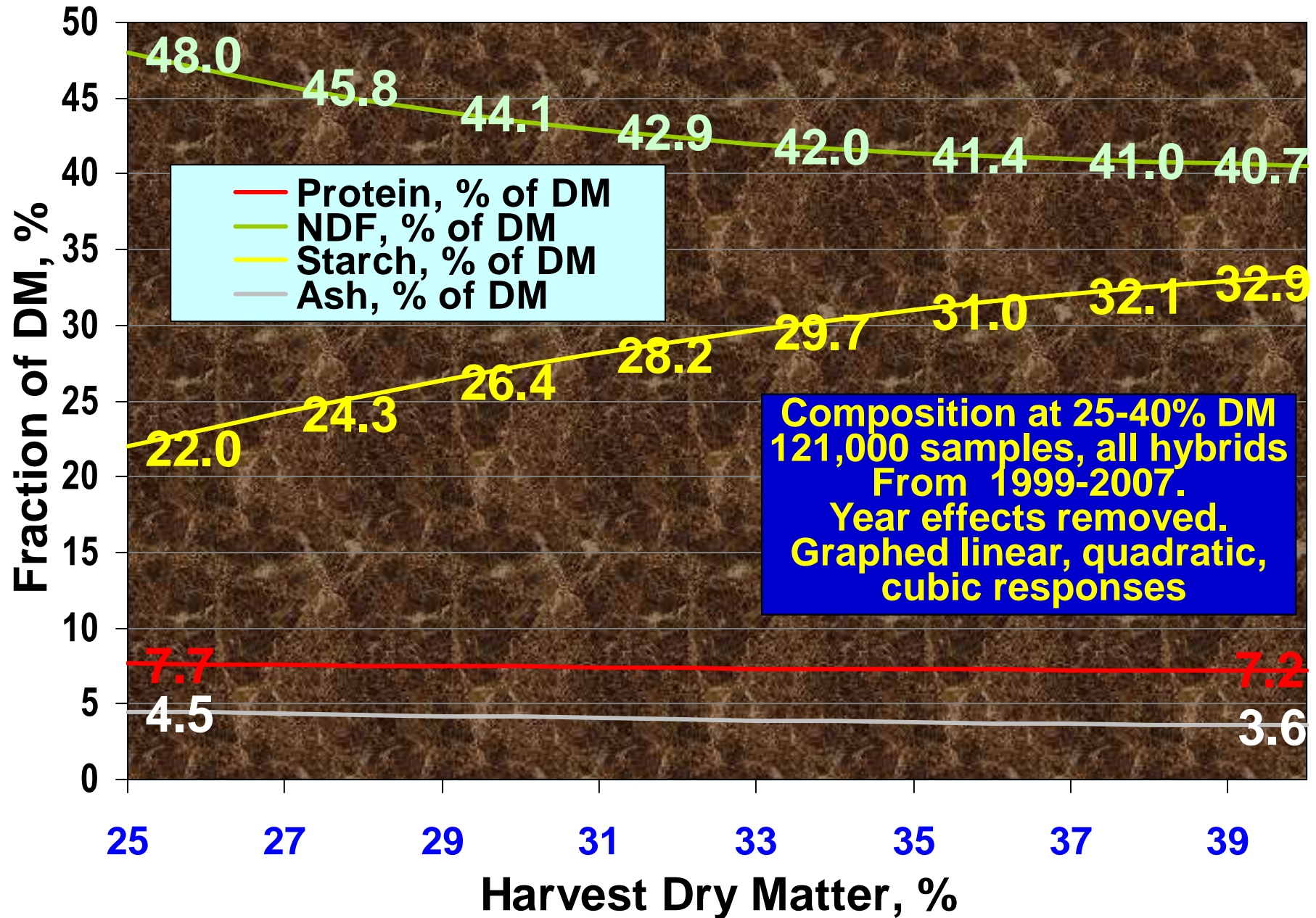


**Chopper-mounted NIR for quality and yield evaluation of silage hybrids.**

# Correlation Between Starch and Protein or Oil Content in Pioneer Corn Hybrids (2005 LS Means)



# Corn Plant Composition versus Harvest DM



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- 5. Amino acid estimation through regression against protein content of feeds.**
- 6. Estimating of available energy through automated gas production measurements (esp. byproducts).**

# In vitro Gas Production Curves

## QUADRANT I

Quadrant (and Kd's) where cows are typically milking well, but watch for any sudden changes in feed delivery or consistency

### Symptoms

- Good manure consistency
- High dry matter intakes (DMI)
- Excellent milk yield
- Exceptional feed conversion ~ 1.7

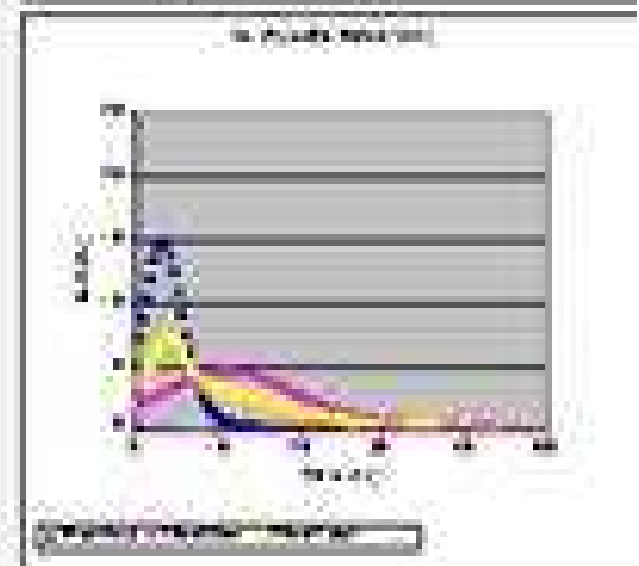
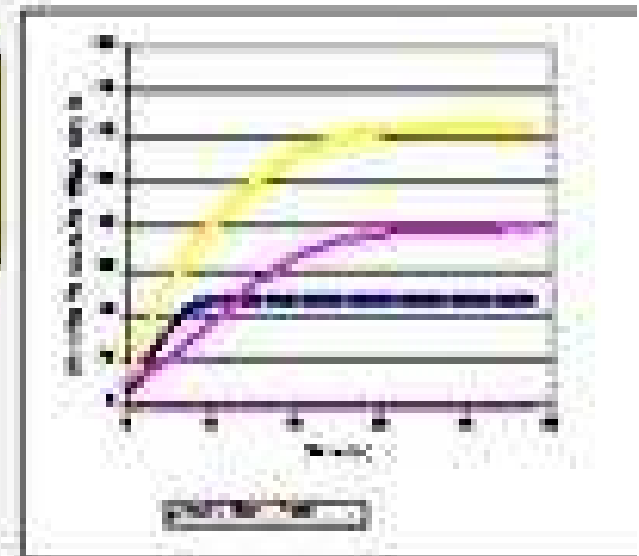
### TMR Rates

CB1 Kd: 18 – 20%/hr

CB3 Kd: 5 - 6%/hr

### Consider

- Ensure enough NPN and peptides to feed rumen bacteria.



# In vitro Gas Production Curves

## QUADRANT I

Quadrant (and Kd's) where cows are typically milking well, but watch for any sudden changes in feed delivery or consistency

### Symptoms

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- High dry matter intakes (DMI)
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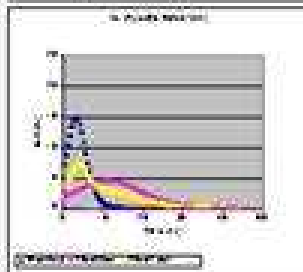
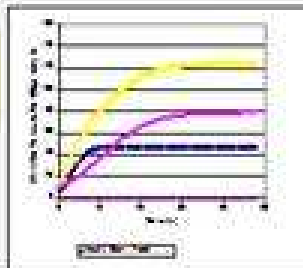
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### Consider

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## QUADRANT II

Not enough energy

### Symptoms

- Grain in manure
- Low milk protein
- Milk yield lower than expected
- Rough hair coats
- Poor reproduction

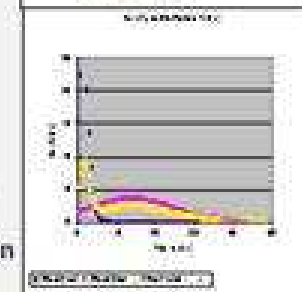
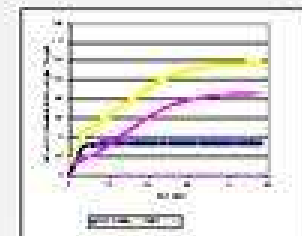
### TMR Rates

Small pool of CB1 that disappears quickly

CB3 Kd: 5 - 6%/hr

### Consider

- Increasing supply of rumen available starch and sugar (get B1 rates closer to 20-22%)
- Grinding grains finer
- Ensure adequate supply of peptide & NPN protein



## QUADRANT III

Where the majority of "problem" herds reside. High acidosis potential due to a fast "fast pool" and a slow "slow pool"

### Symptoms

- Sore Feet - Repro problems - Poor DMI
- Ketosis in early lactation cows
- Fiber in Manure - Low rumen pH
- Variability in body condition score
- Fat/Protein Inversion in >10% of the herd

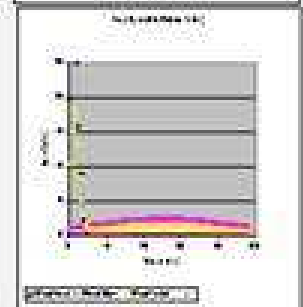
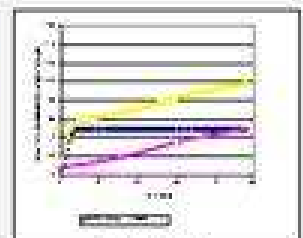
### TMR Rates

CB1 Kd: >25%/hr

CB3 Kd: <5%/hr

### Consider

- Increase NDFD by adding non-forage fiber
- Beet Pulp, Brewers Grains, Soyhulls
- Slow B1 to <21%



## QUADRANT IV

Slow "fast pool" and Slow "slow pool"

### Symptoms

- Poor milk production
- Early peak/poor peak milk
- Cows "look" OK
- Diet CP is OK - but manure is stiff
- Average milk components
- Very expensive ration per CWT
- Reproduction- delayed, but not bad

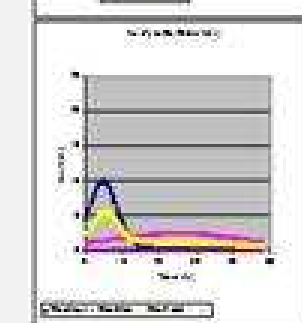
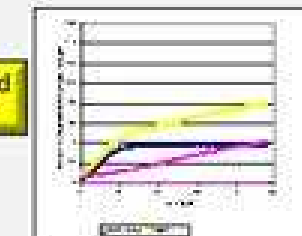
### TMR Rates

CB1 Kd: <15%/hr

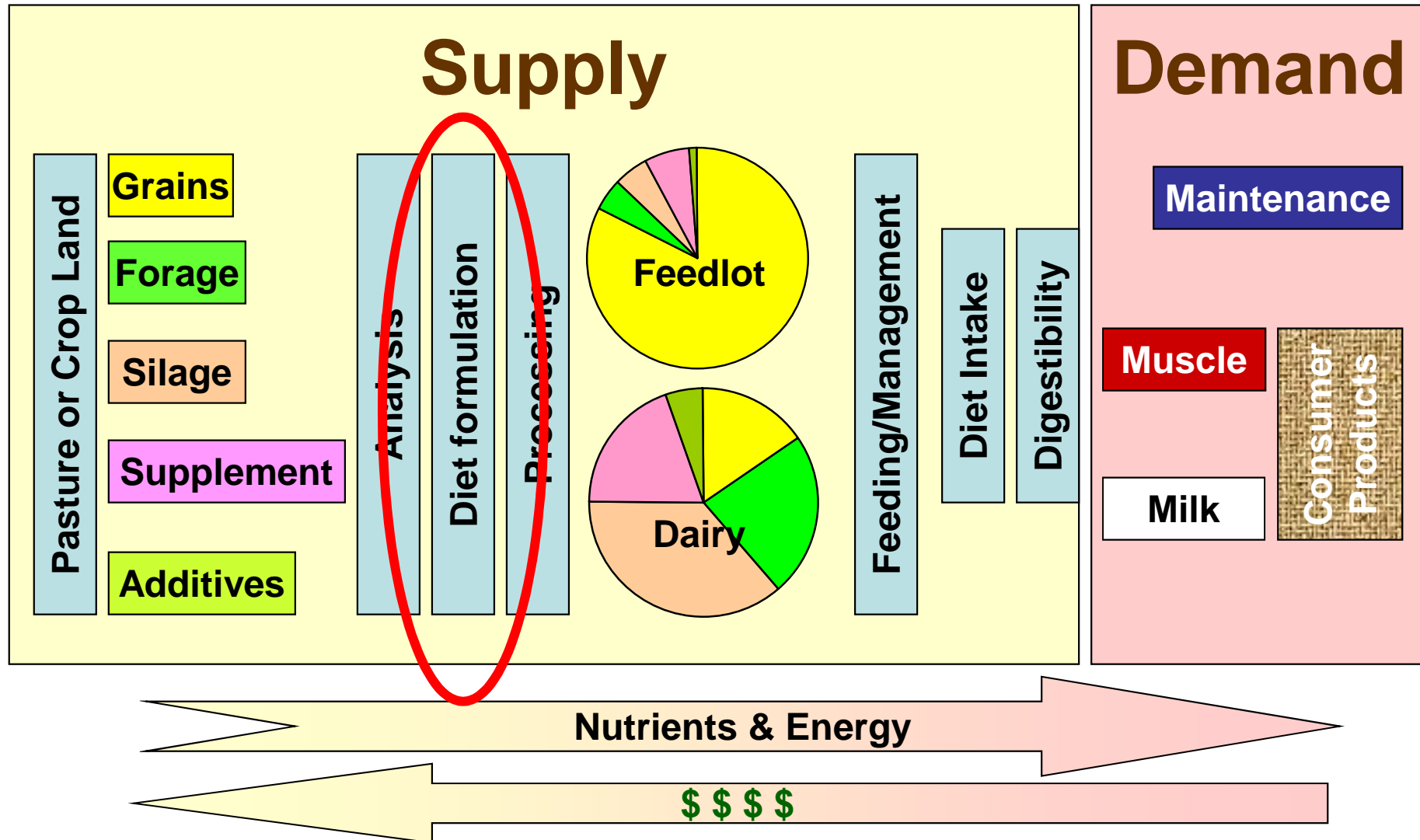
CB3 Kd: <5%/hr

### Consider

- Increasing rumen available starch and sugar
- Grind grains finer
- Increase NDFD by adding non forage fiber
- Add beet pulp, brewers, soyhulls, more digestible forages



# Balance of Energy & Nutrients



# Advances in Diet Formulation

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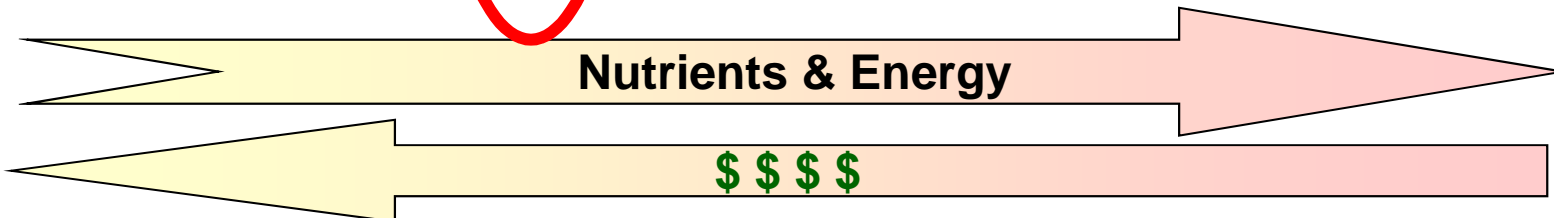
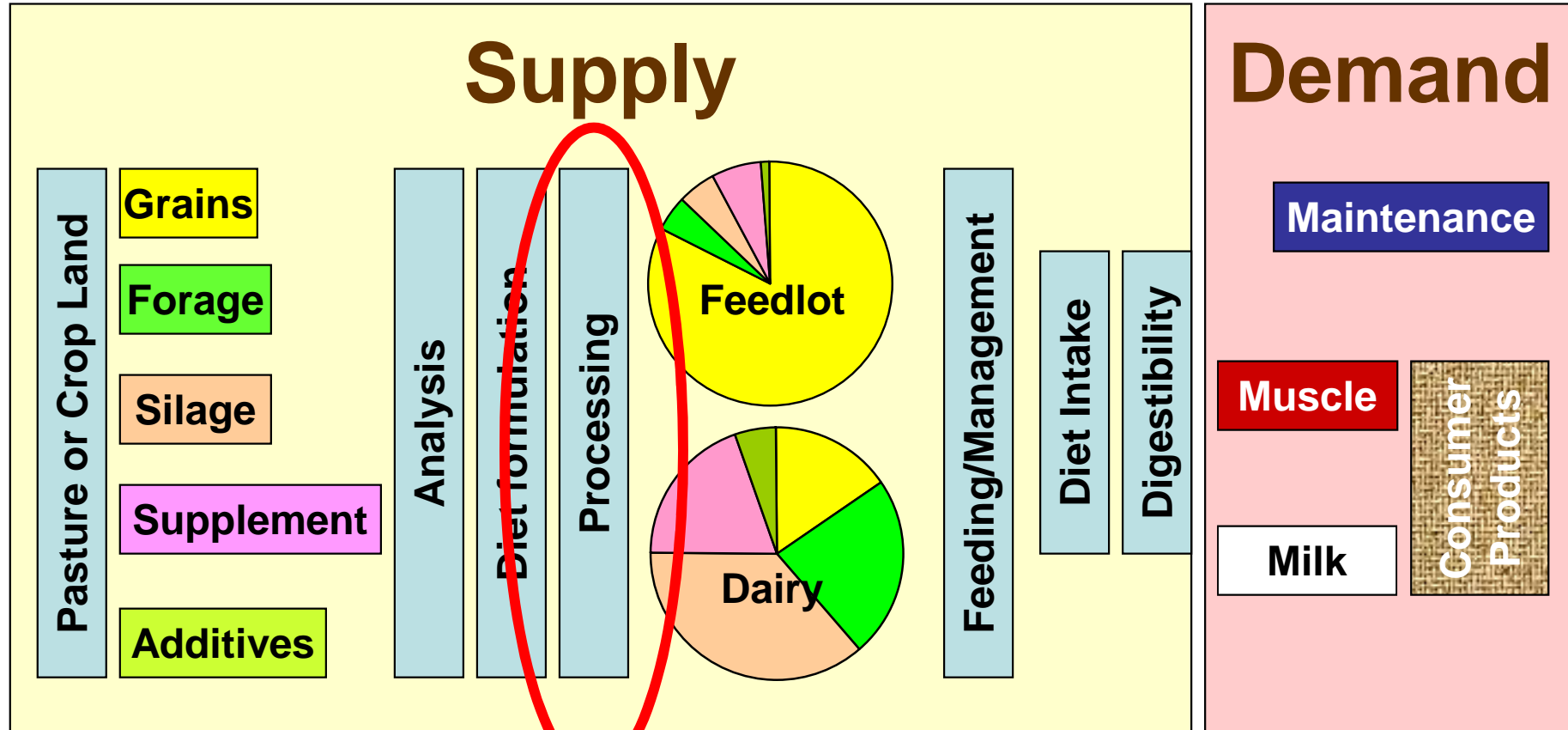
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- 4. Appraisal of energy contents of diets through measuring performance and efficiency of cattle.**

# Balance of Energy & Nutrients



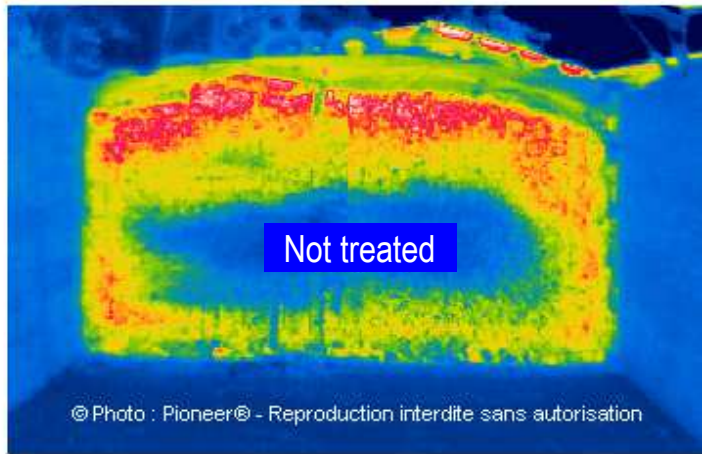
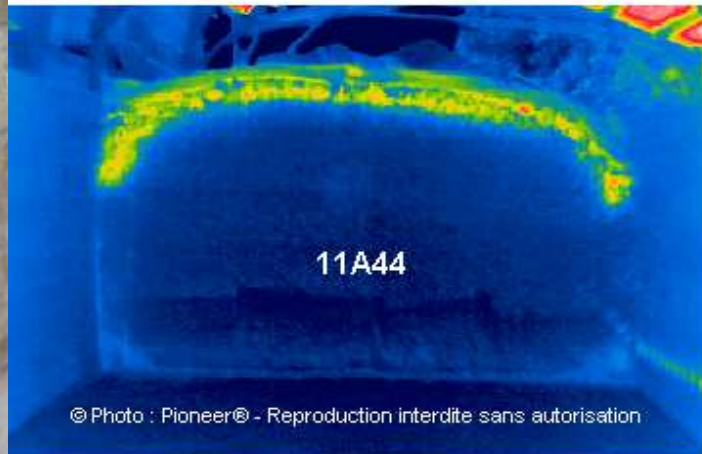
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# L. buchneri and Heating of Corn Silage

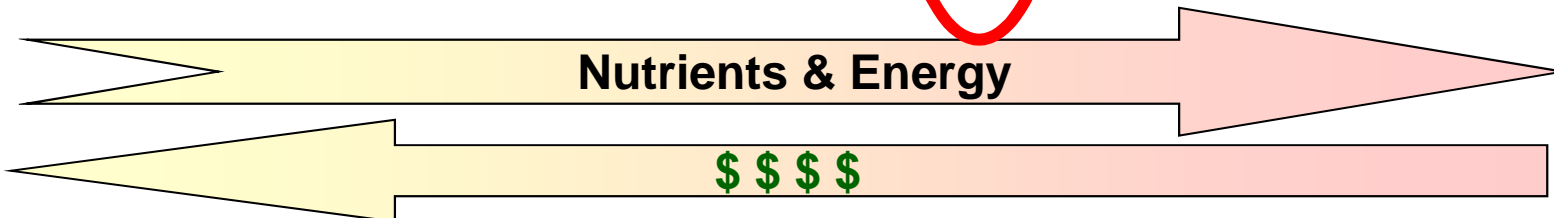
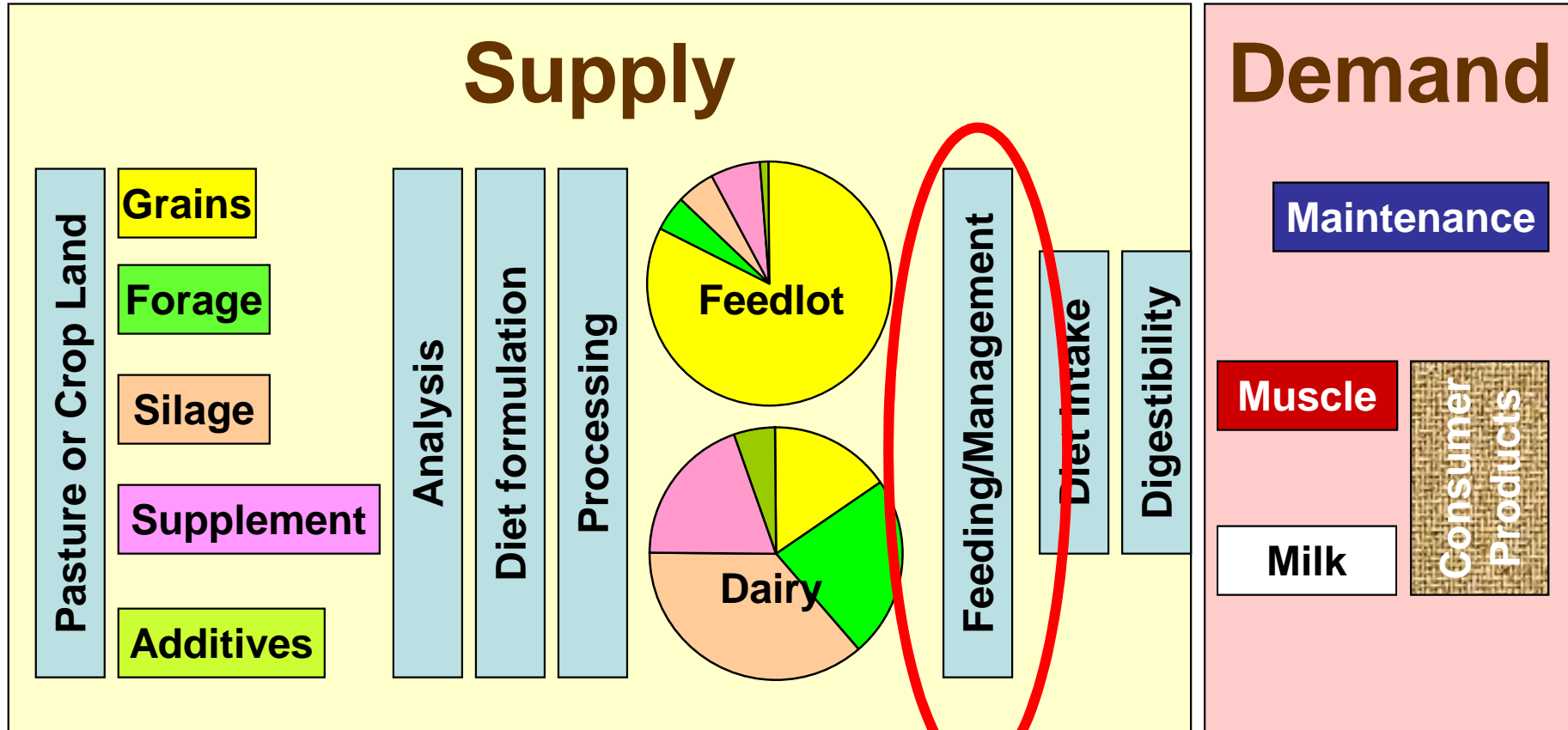


Source : PIONEER SEMENCES, INRA du PIN et INFRAROUGE RECHERCHES INTERNATIONAL, non publiée  
red to blue = range of 20° C

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- 3. Solubilization of fiber through treatment with enzymes or bases (ammonia, slack lime, NaOH).**

# Balance of Energy & Nutrients



# Advances in Feed Delivery

1. **Total mixed rations for dairy cows to reduce feed sorting.**

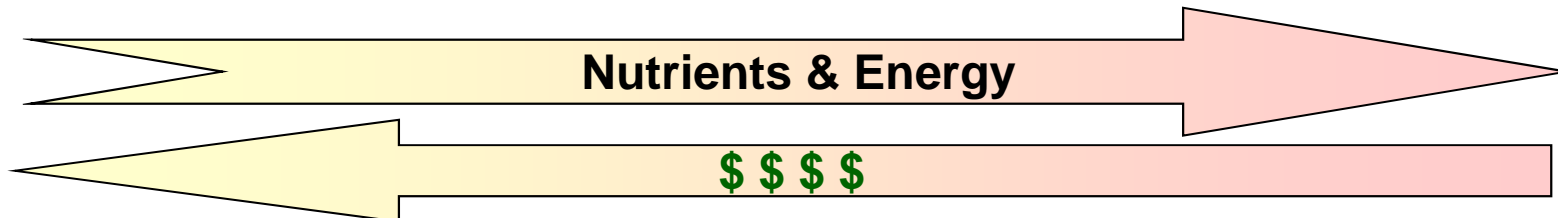
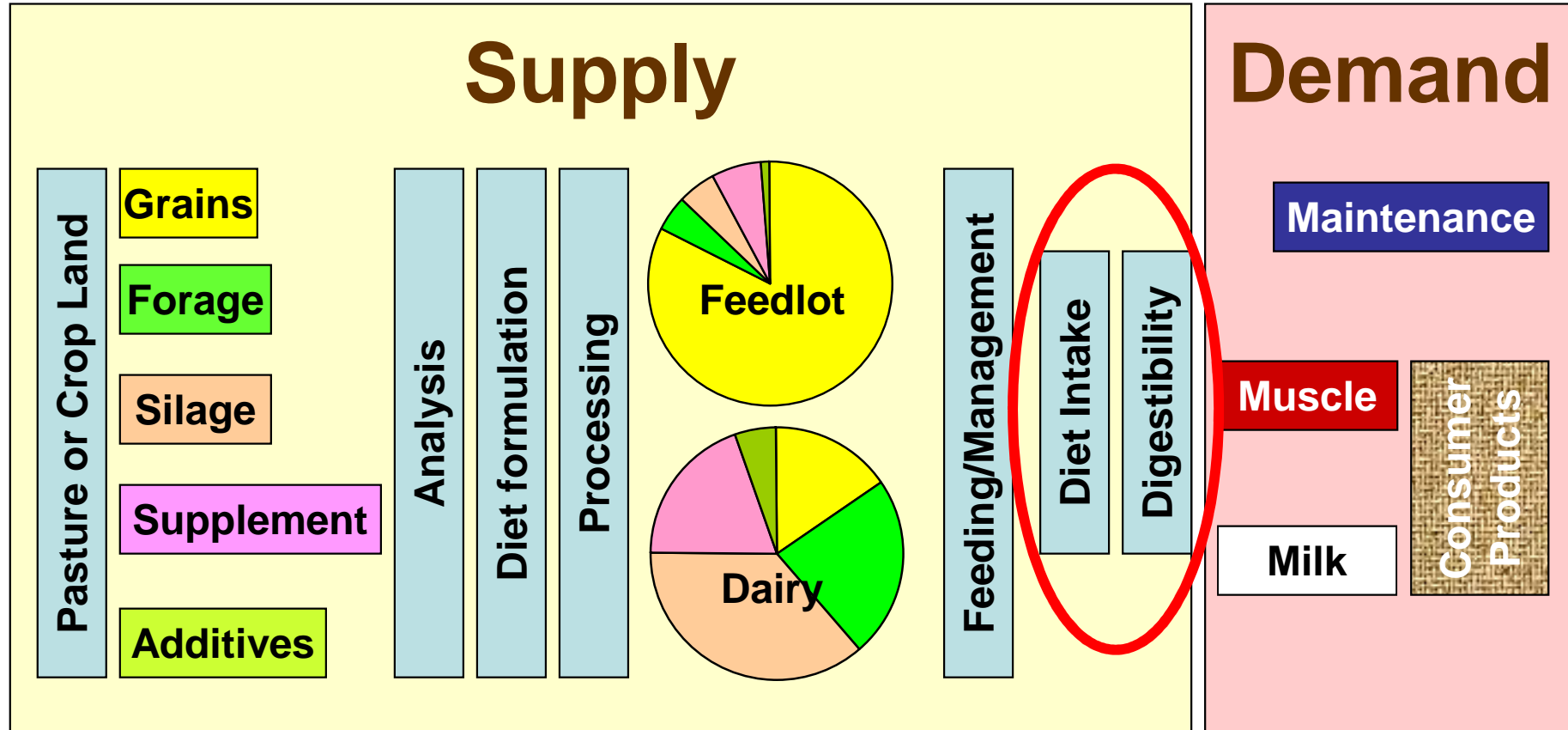
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- 3. Limit feeding concentrate diets for dry cows and during slow growth to increase feed efficiency while reducing forage handling, labor, and diet cost.**

# Balance of Energy & Nutrients



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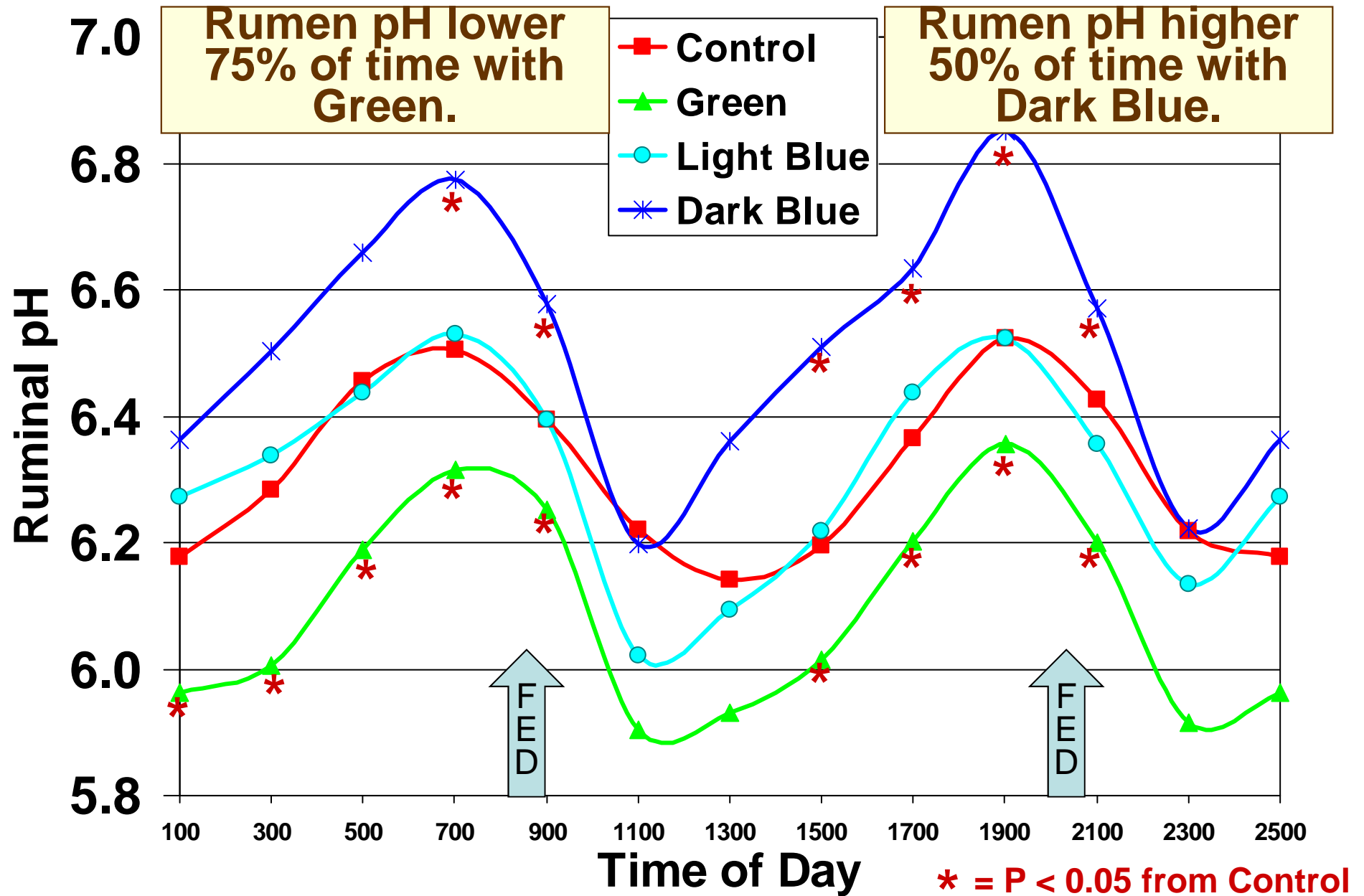
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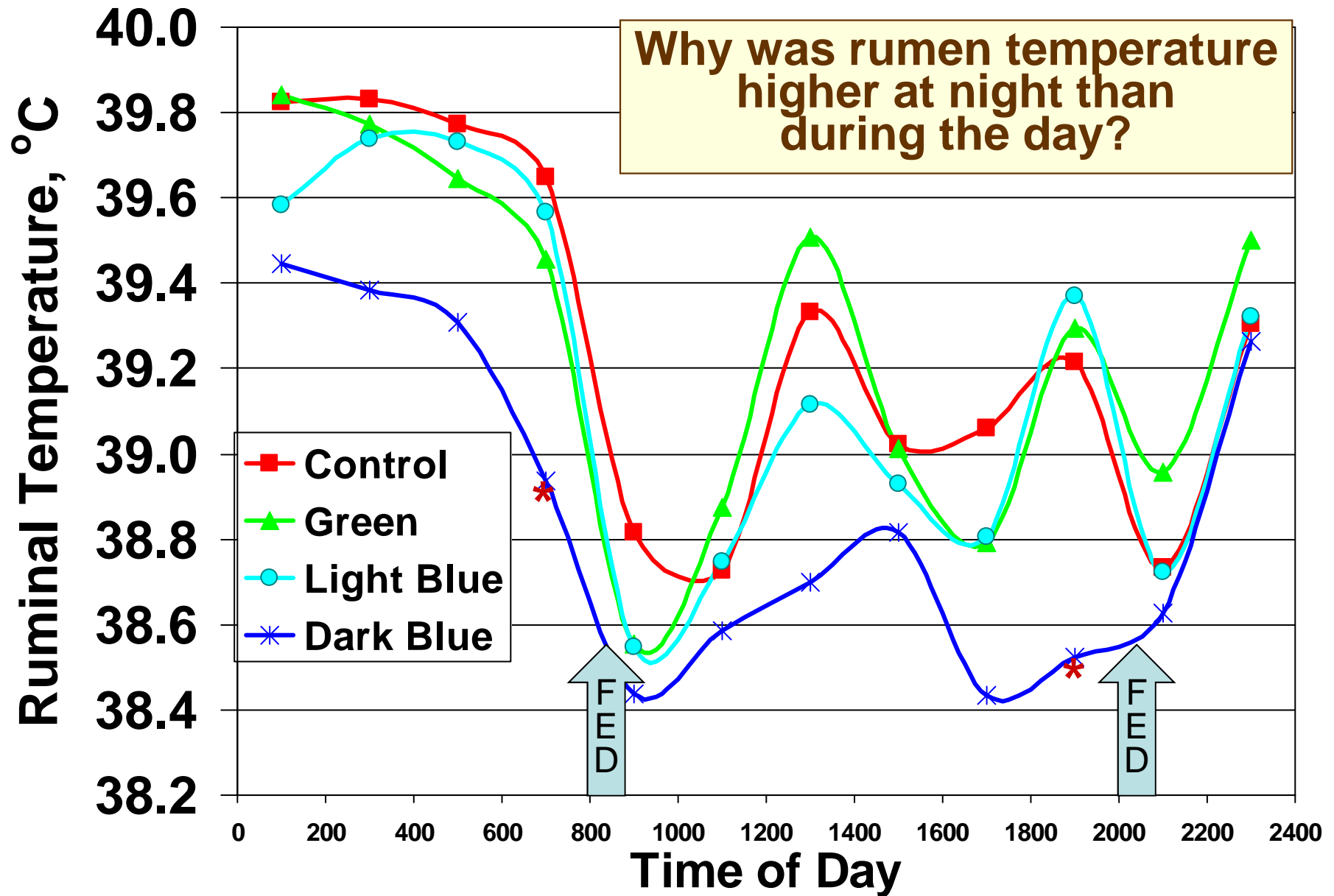
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- 5. Rumen pH, eH, ammonia stabilizers.**

# Additive Effects on Ruminal pH (7 d; 4x4LS)



# Additive Effects on Ruminal Temperature



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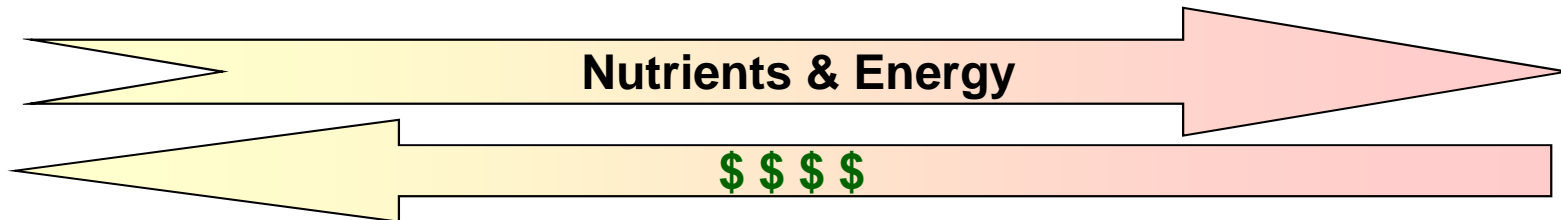
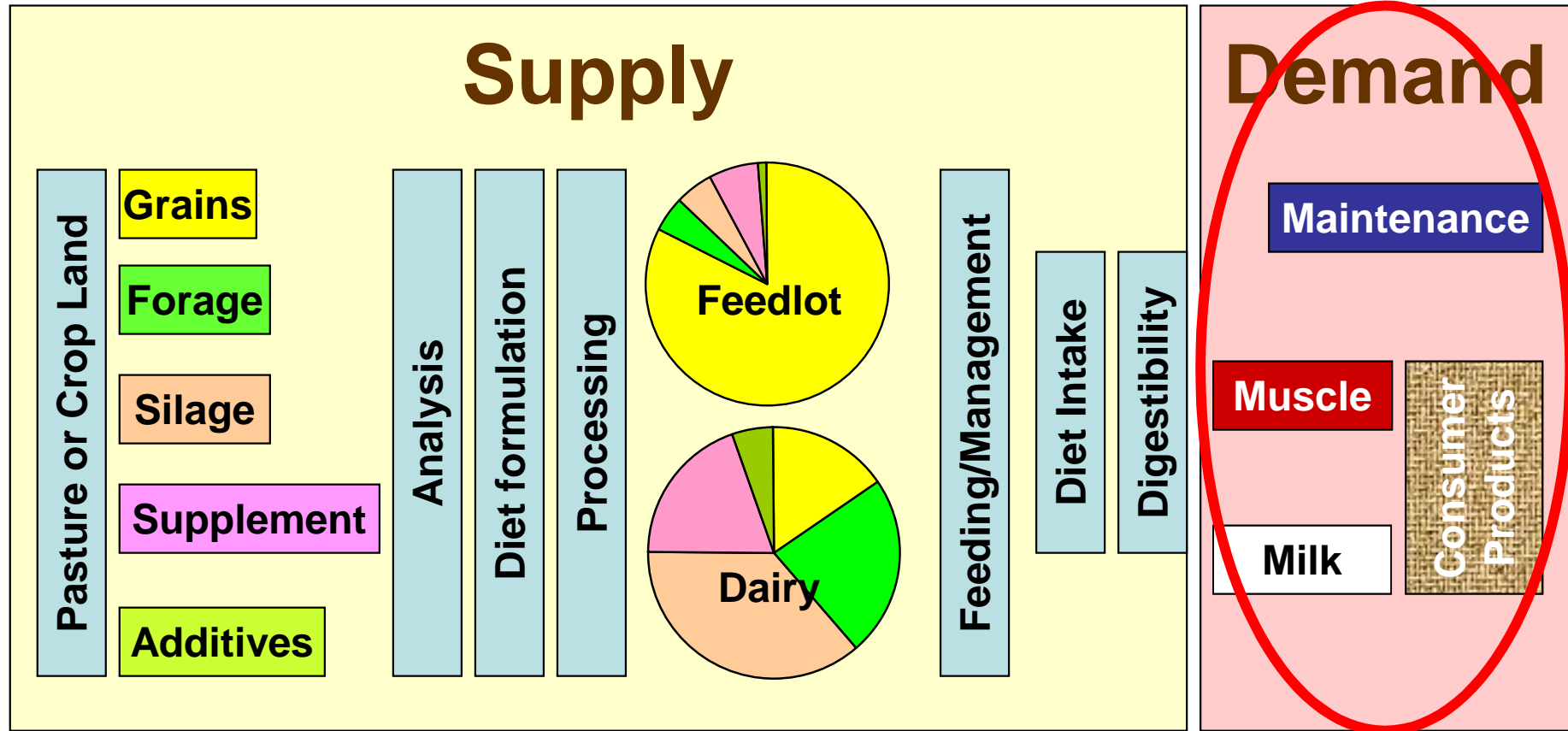
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- 4. Avoiding high tannin products (sorghum, sorghum sudan).**

# Balance of Energy & Nutrients



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**This suggests that animals regulate FEED INTAKE to meet their NEEDS.**

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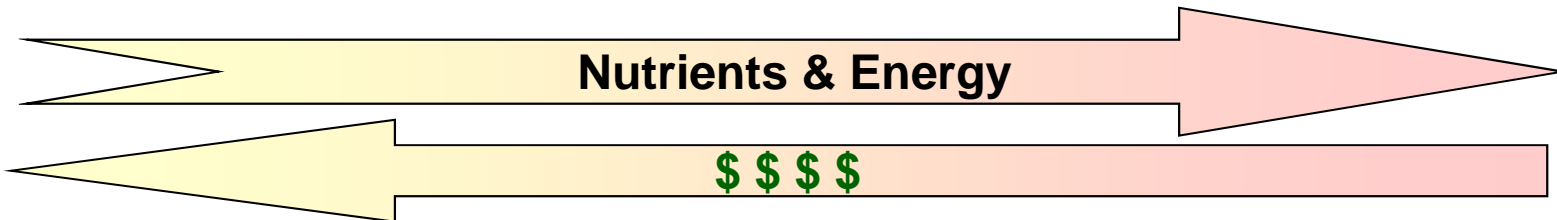
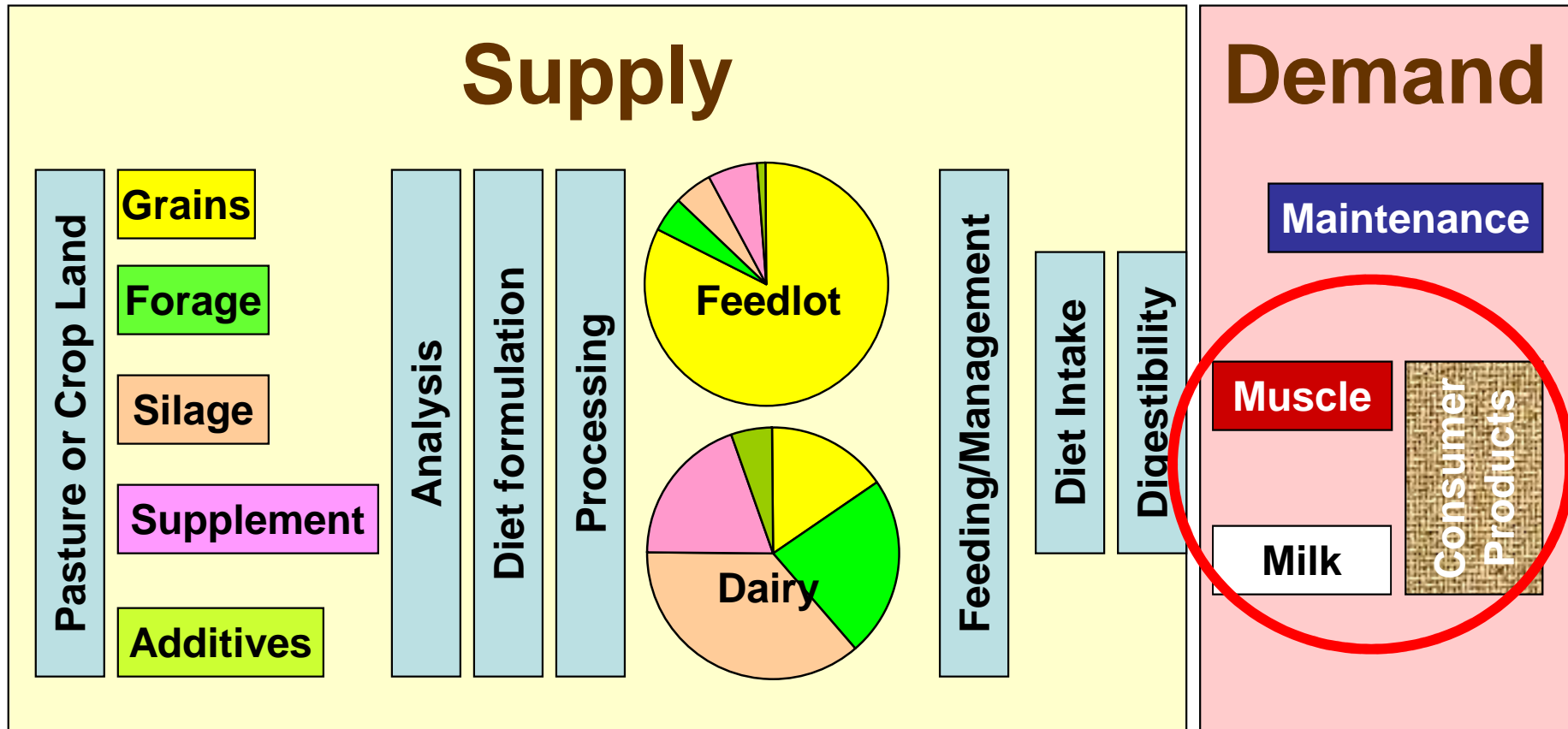
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- 4. Repartitioning agents (bovine growth hormone; beta agonists).**

# Balance of Energy & Nutrients



# Advances in “Presumed” Product Healthfulness

1. **Direct fed microbes that compete with or inhibit pathogenic bacteria (E. coli).**

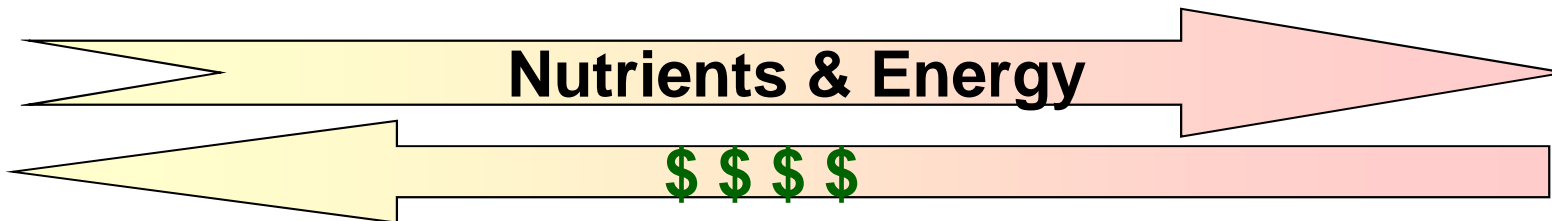
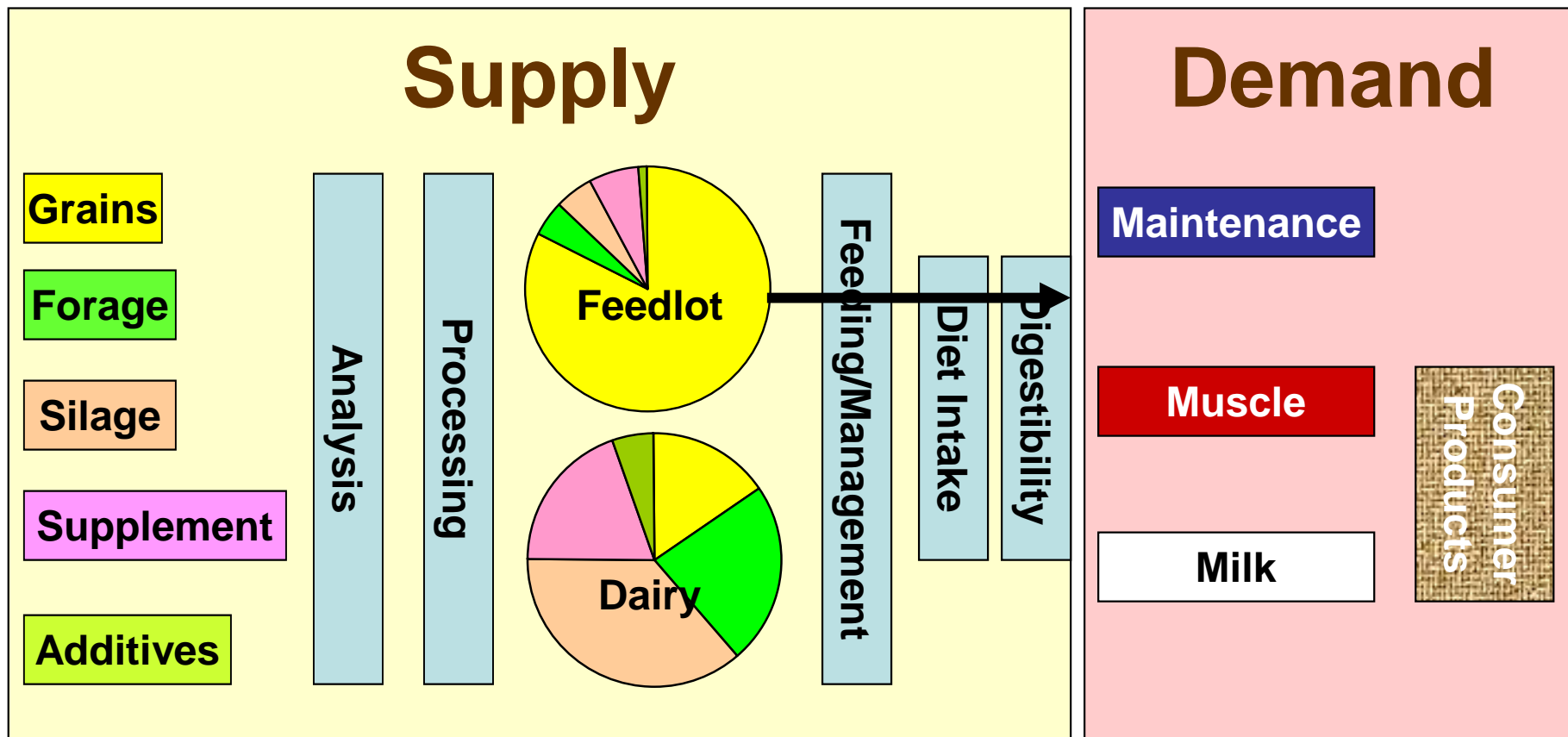
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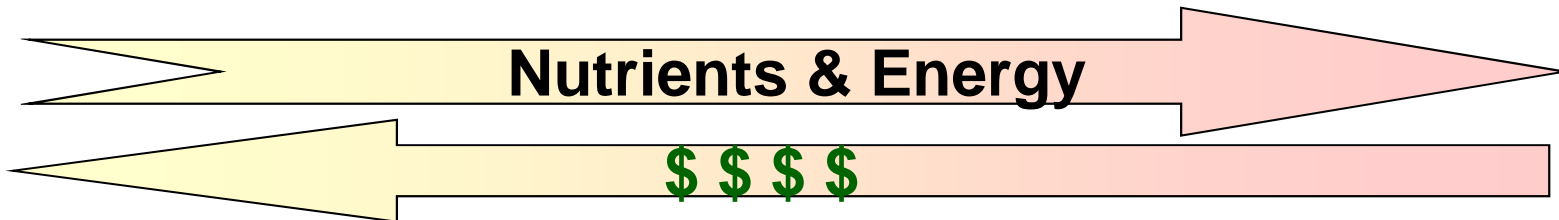
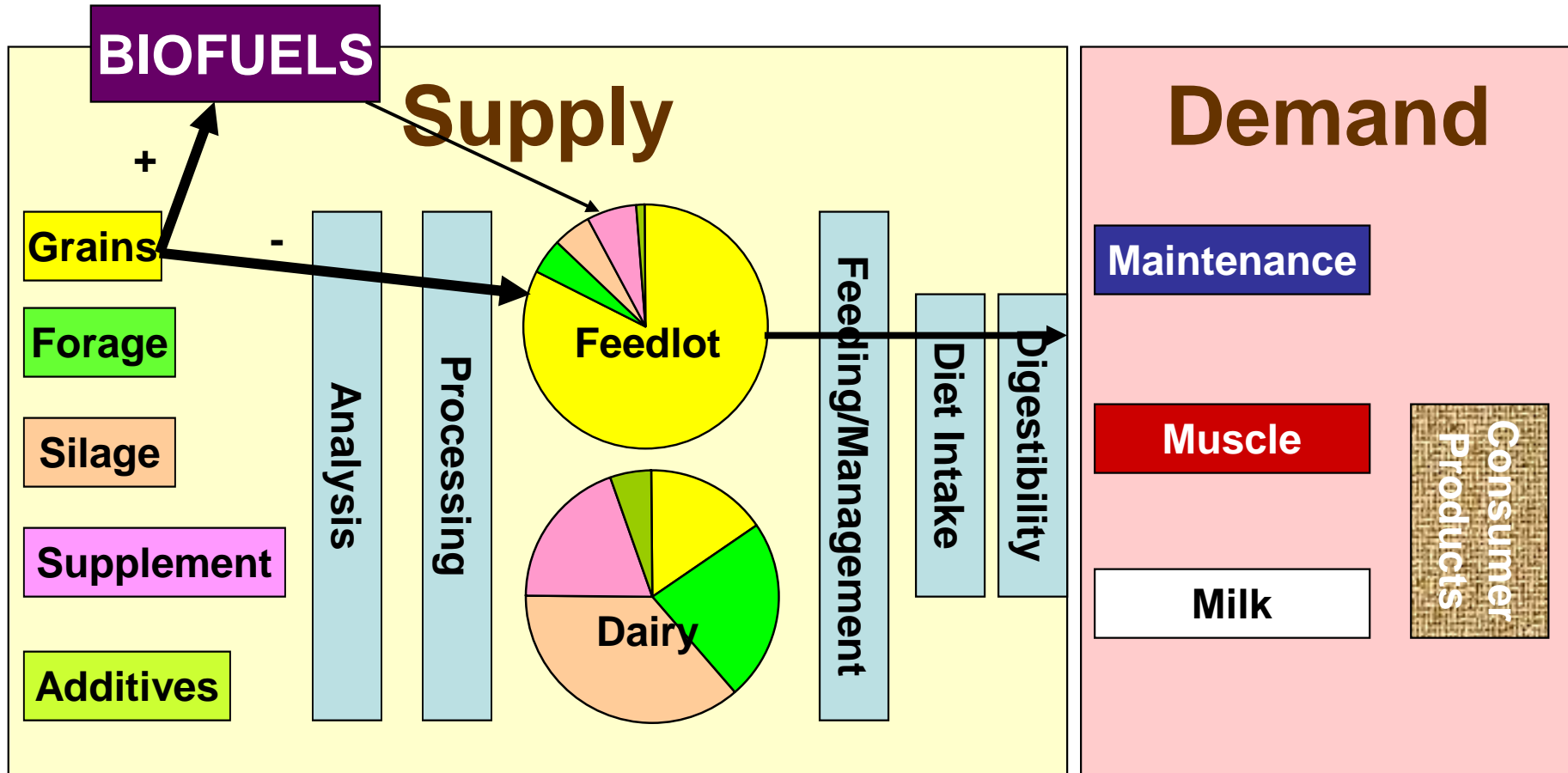
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- 2. Increased CLA concentrations of milk, meat.**
- 3. Less saturated fatty acids or higher concentrations of desired fatty acids in milk/meat through feeding of specific oilseeds or protected lipids.**

# Challenge: Competition for Energy



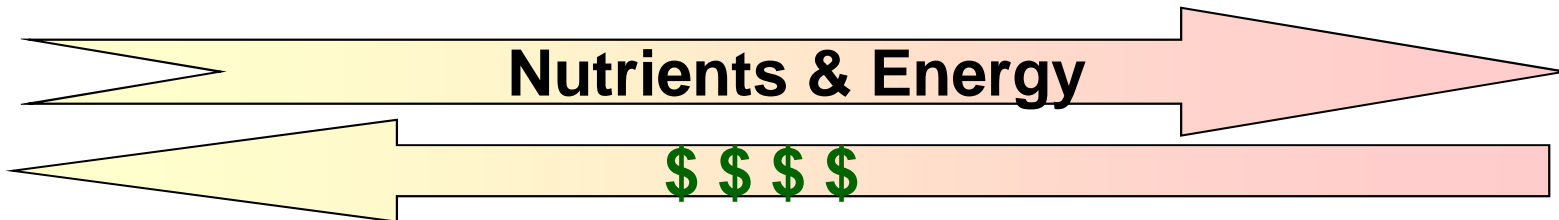
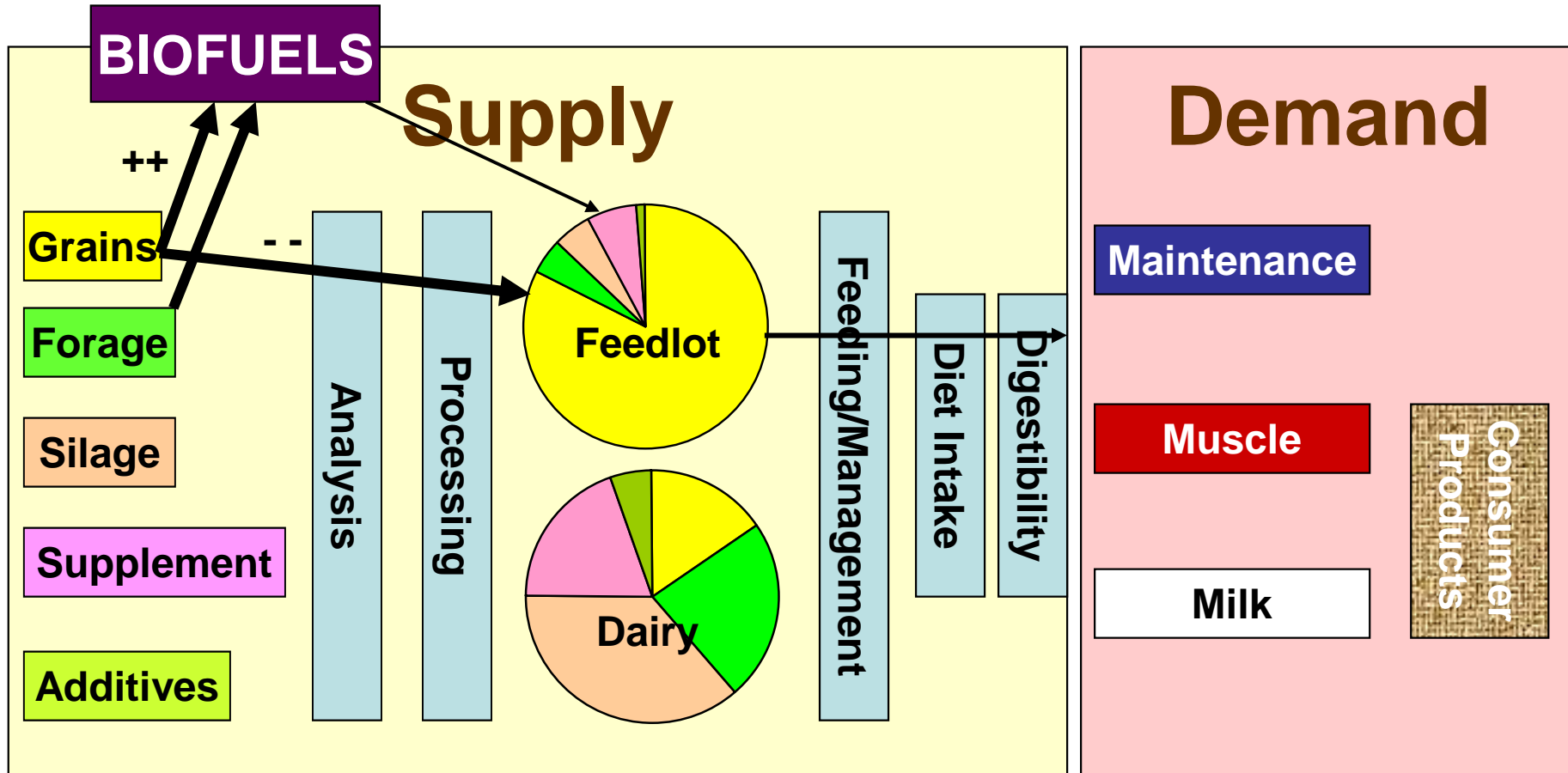
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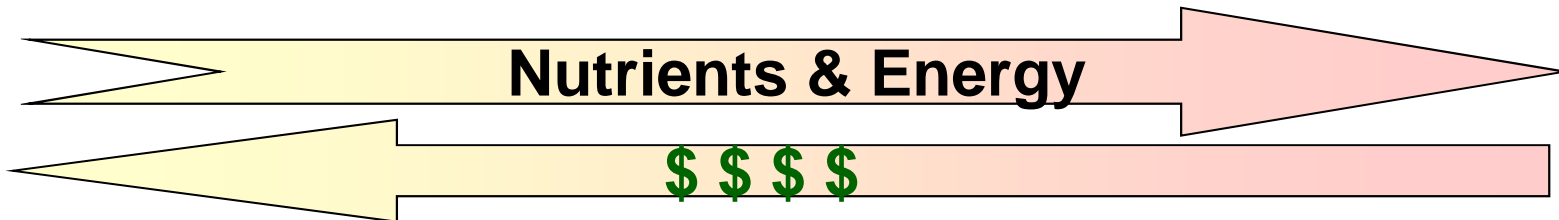
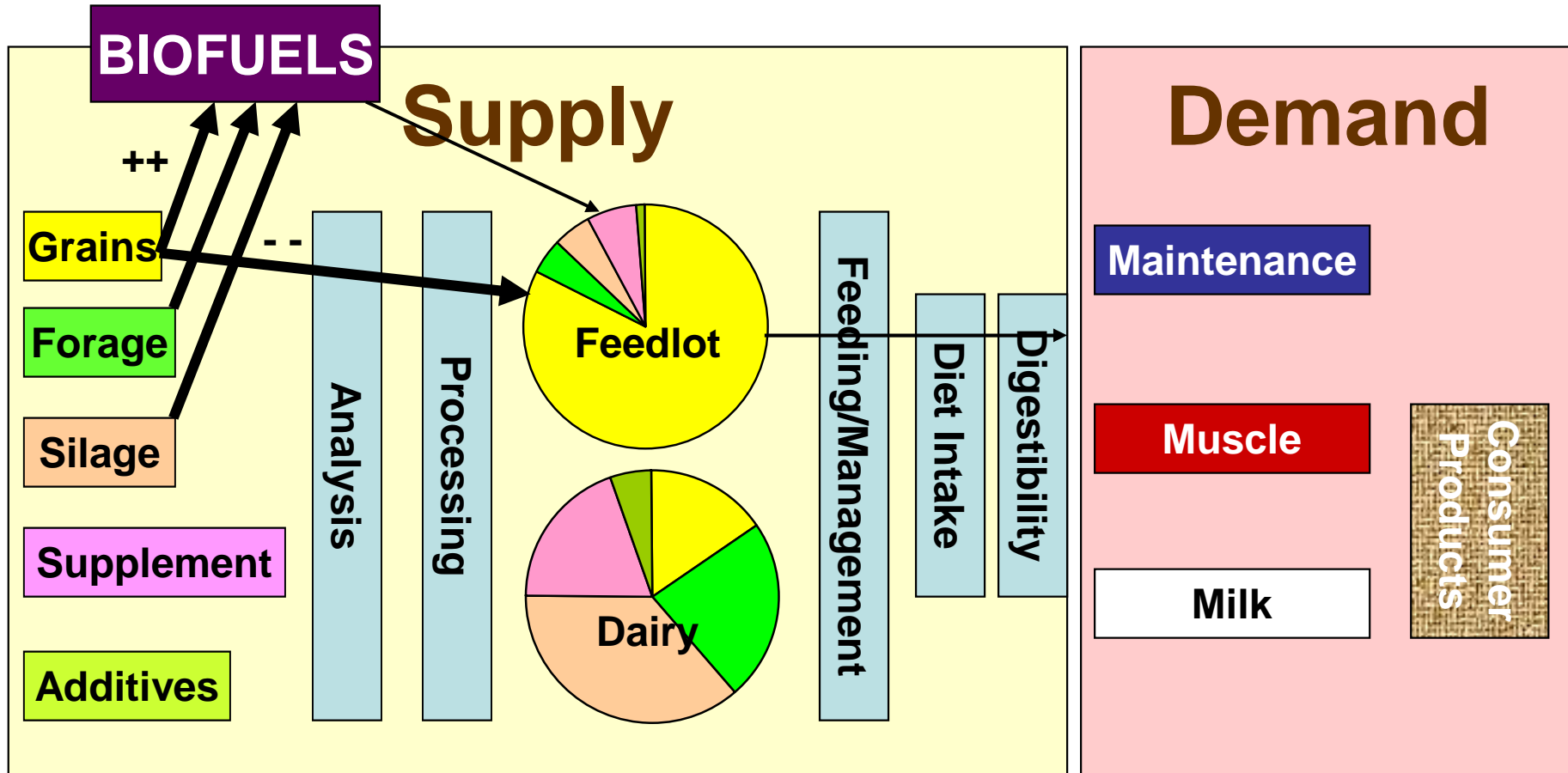
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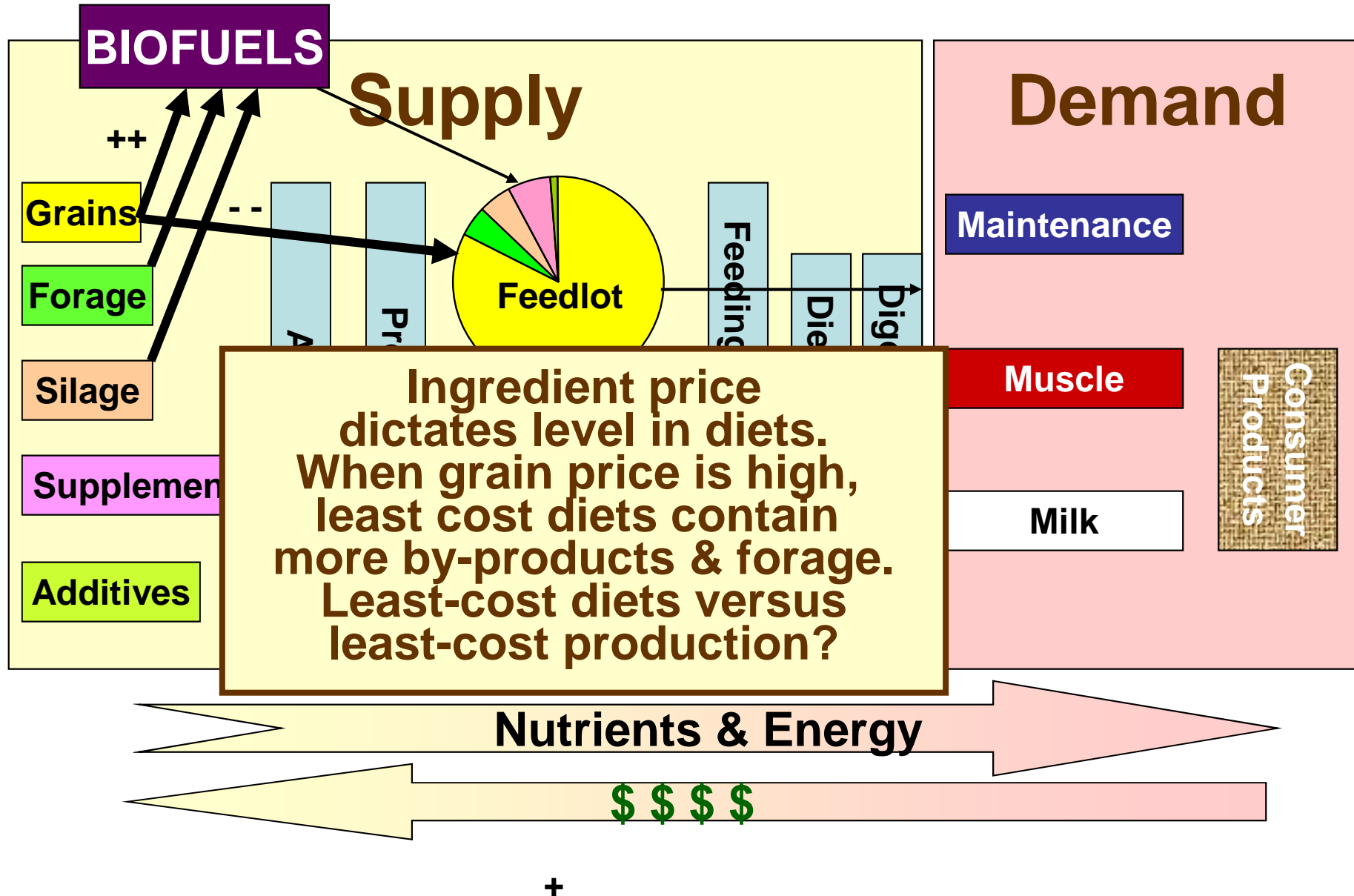
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+

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# Discoveries that have Contributed to Animal Production & Efficiency

**Animal:** Genetic selection and improvement; Artificial insemination; Animal classification & identification; Estrogens/androgens; Gene markers & modification; Repartitioning agents.

**Animal health:** Antibiotics/Ionophores; Vaccines/animal health products; Immune stimulants; Specific antibodies.

**Diets and management:** Large scale production units; Refined nutrient requirements; Feed analysis systems; Diet formulation models; Feed processing & delivery devices; Probiotics, enzymes, mycotoxin binders.

**Energy availability:** High plant and grain yields, plant breeding and hybridization; Byproducts.

# Conclusions

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- 4. Ingredient prices will dictate the amounts of various commodities fed to livestock.**

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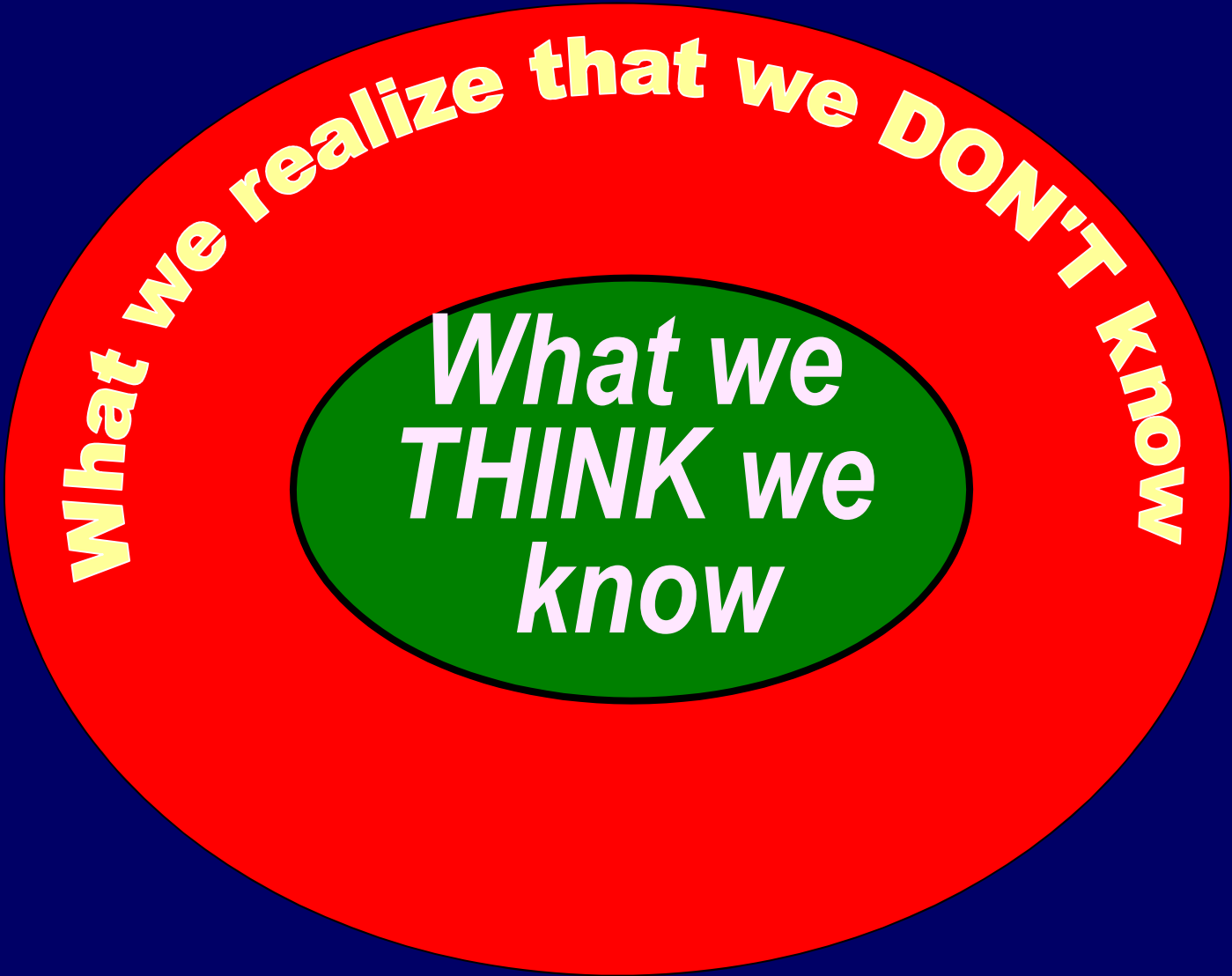
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- 6. Only those byproducts and residues unsuitable for generating energy will remain available for ruminants.**
- 7. Environmental regulations (air, water quality) will alter composition of diets locally.**
- 8. Feed treatments and feed additives that increase the production: maintenance ratio, energy intake, digestibility, and value to consumers will be used more extensively.**

# *Bodies of Scientific Knowledge*

*What we  
**THINK** we  
know*



What we realize that we DON'T know

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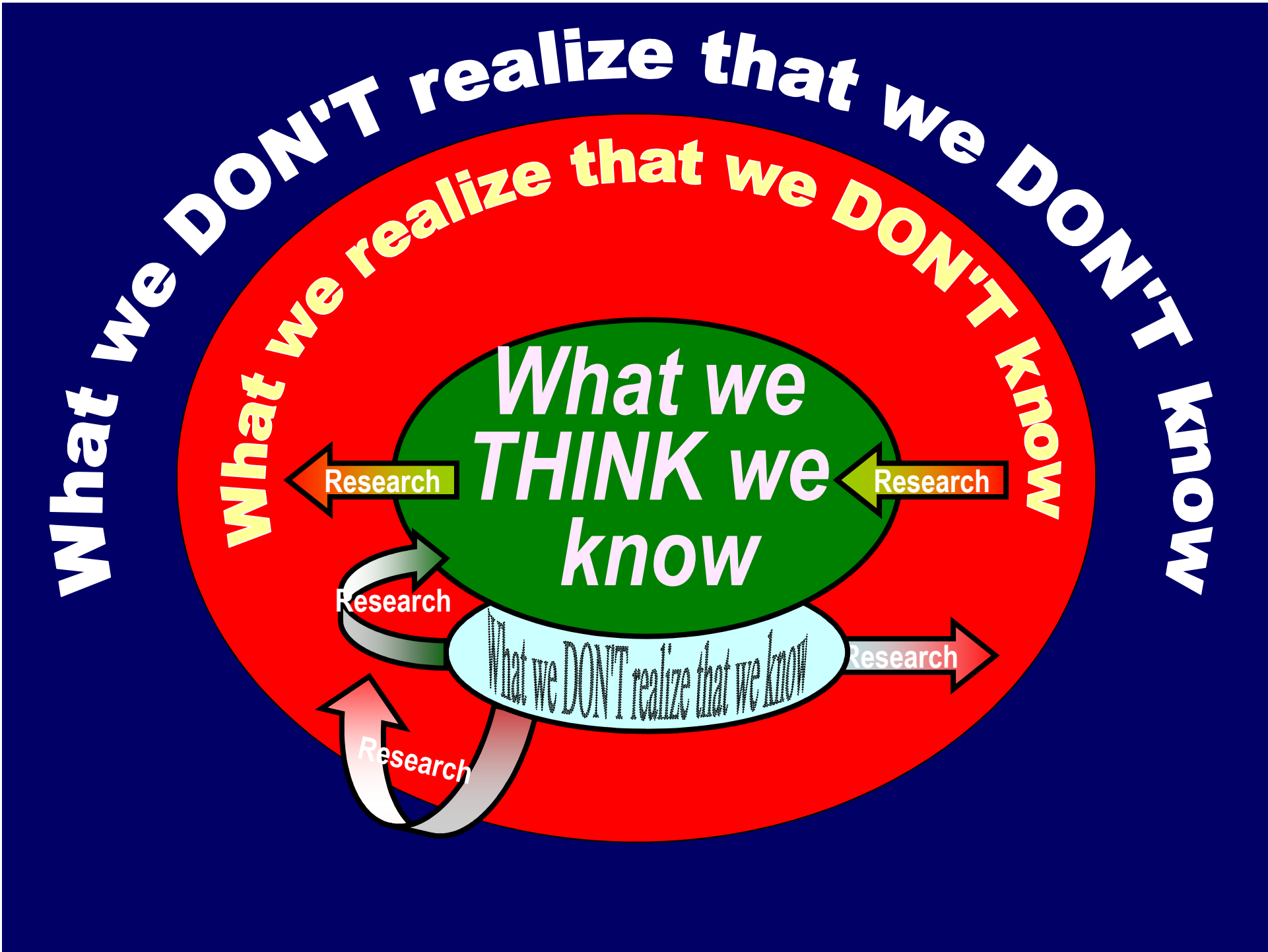
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“Research holds the KEYS to Progress.”

What we DON'T realize that we DON'T know

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“Those who ignore history (the literature) are doomed to repeat it.”

# Gracias.

Though I may not be able to answer your questions, I will try to entertain them!

