Nutrition Strategies for Efficient and Sustainable Production of Poultry Meat and Eggs

Craig Coon

University of Arkansas

NANP Nutrition Summit

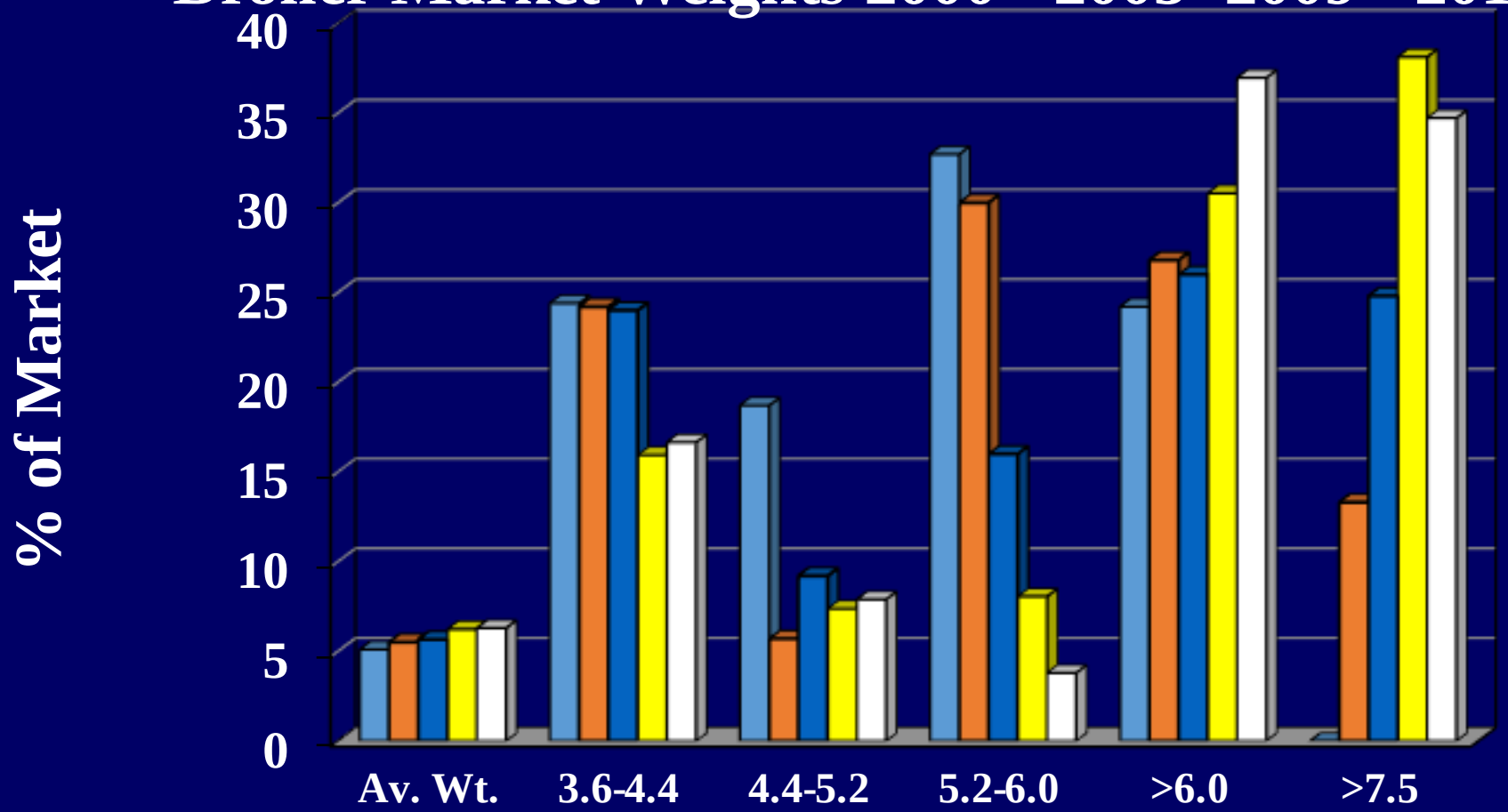
April 10, 2019

National Academy of Sciences, Washington, D.C.

BROILERS

Broiler Feeding Strategies in U.S. Are Different Than in Other Countries

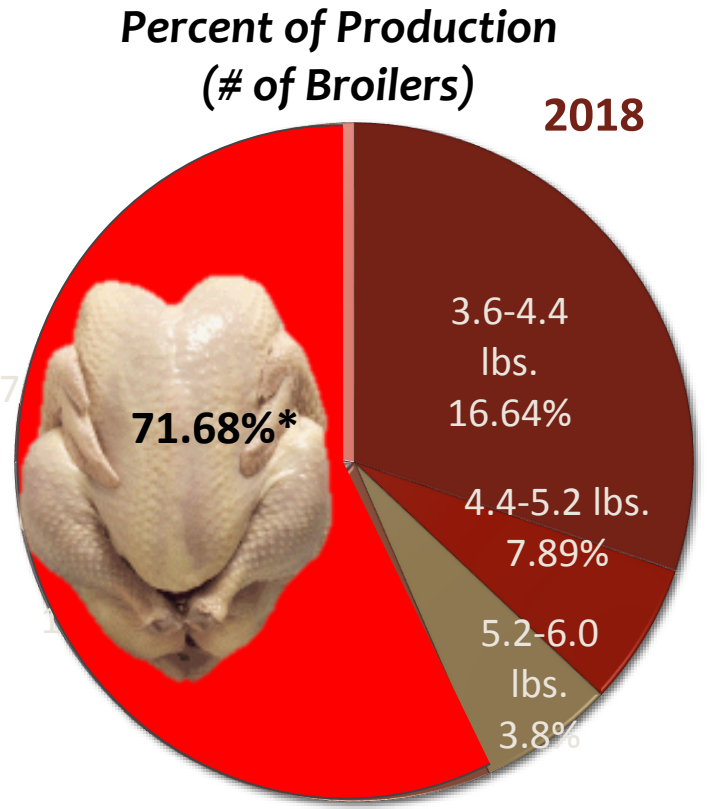
Broiler Market Weights 2000 - 2005 -2009 - 2015 - 2018



	Av. Wt.	3.6-4.4	4.4-5.2	5.2-6.0	>6.0	>7.5
2000	5.1	24.4	18.7	32.7	24.2	0
2005	5.5	24.2	5.7	30	26.8	13.3
2009	5.65	24	9.2	16	26	24.8
2015	6.23	15.93	7.37	8.05	30.52	38.12
2018	6.29	16.64	7.89	3.79	36.96	34.72

Broiler Market Trends

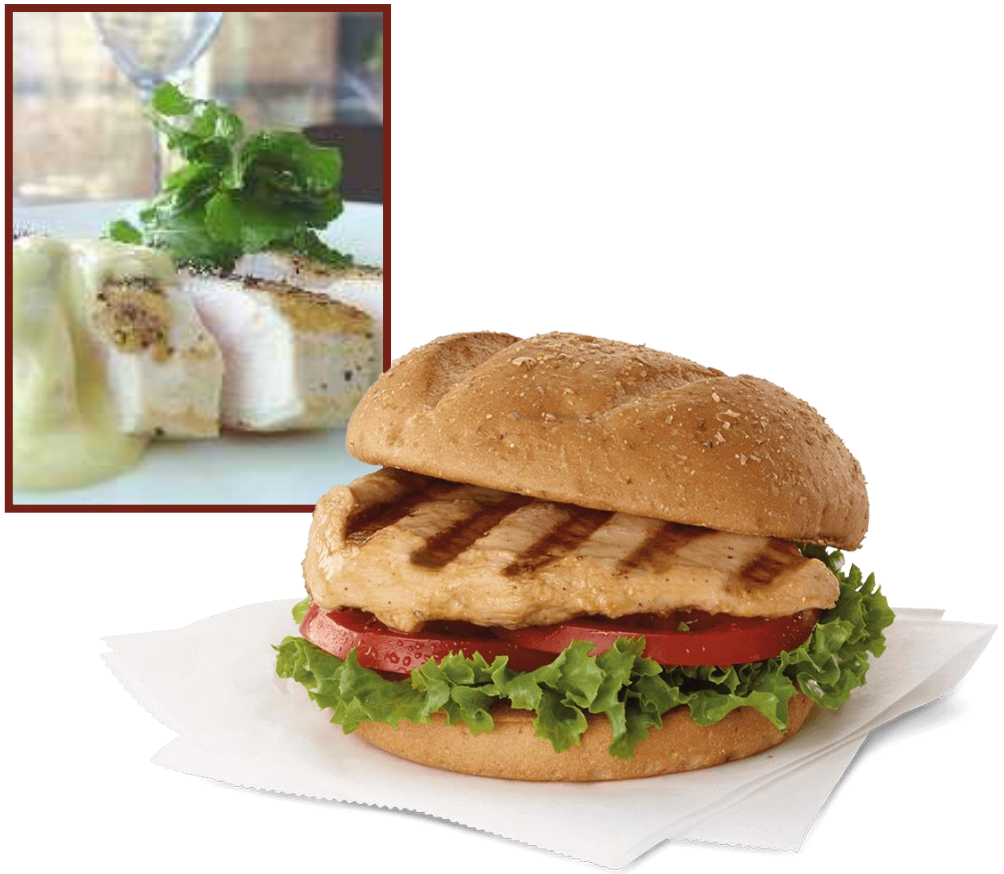
- High breast meat yielding broilers
- Increased bird size
- Shorter growth period (faster growth rate)
- Various markets
- Big bird programs- Large % of U.S. market



*71.7% of meat produced!

> 6 lb: 71.68% in 2018 and 23% in 2000

Boneless Breast Meat in the Market



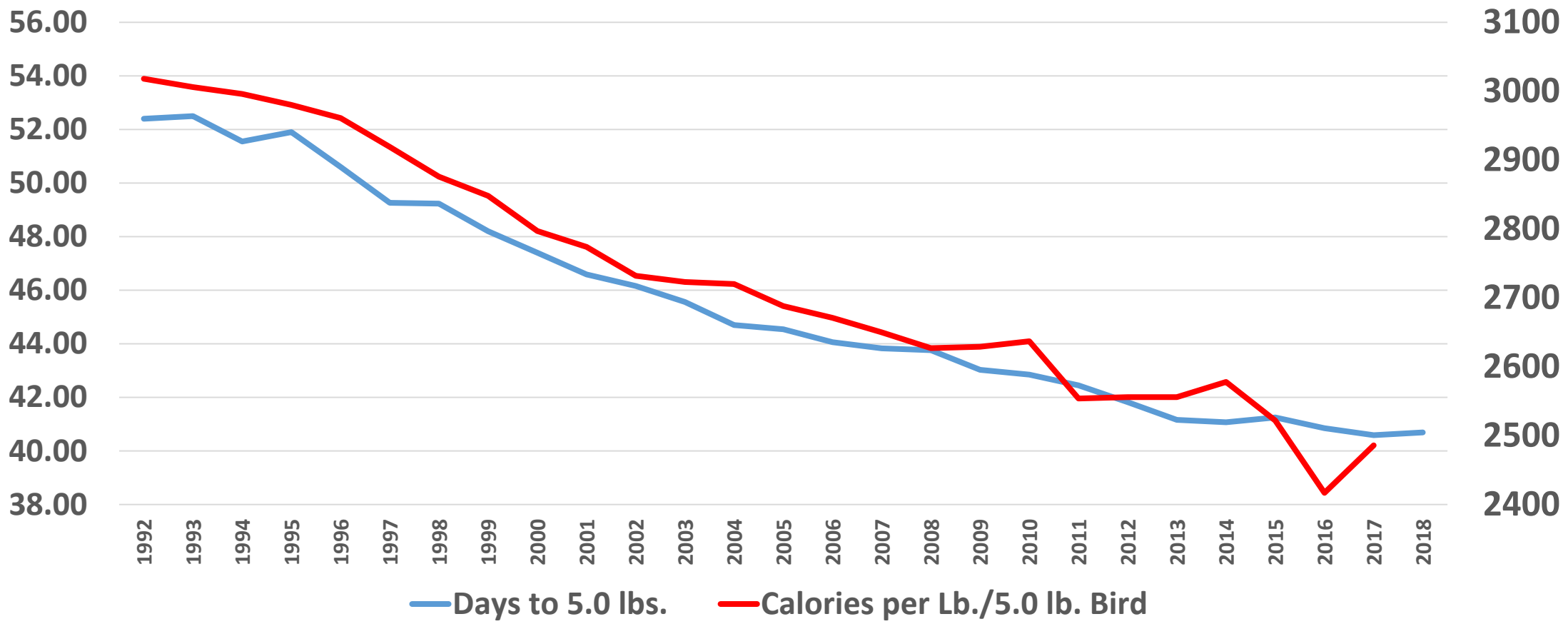
- **Boneless breast meat is the popular meat of choice among the consumers**
  - **Retail fresh, further processed, prepared foods, foodservice**
  - **Portioned breast meat common for foodservice, sourced from larger broilers**

AGRI STATS VITAL SIGNS

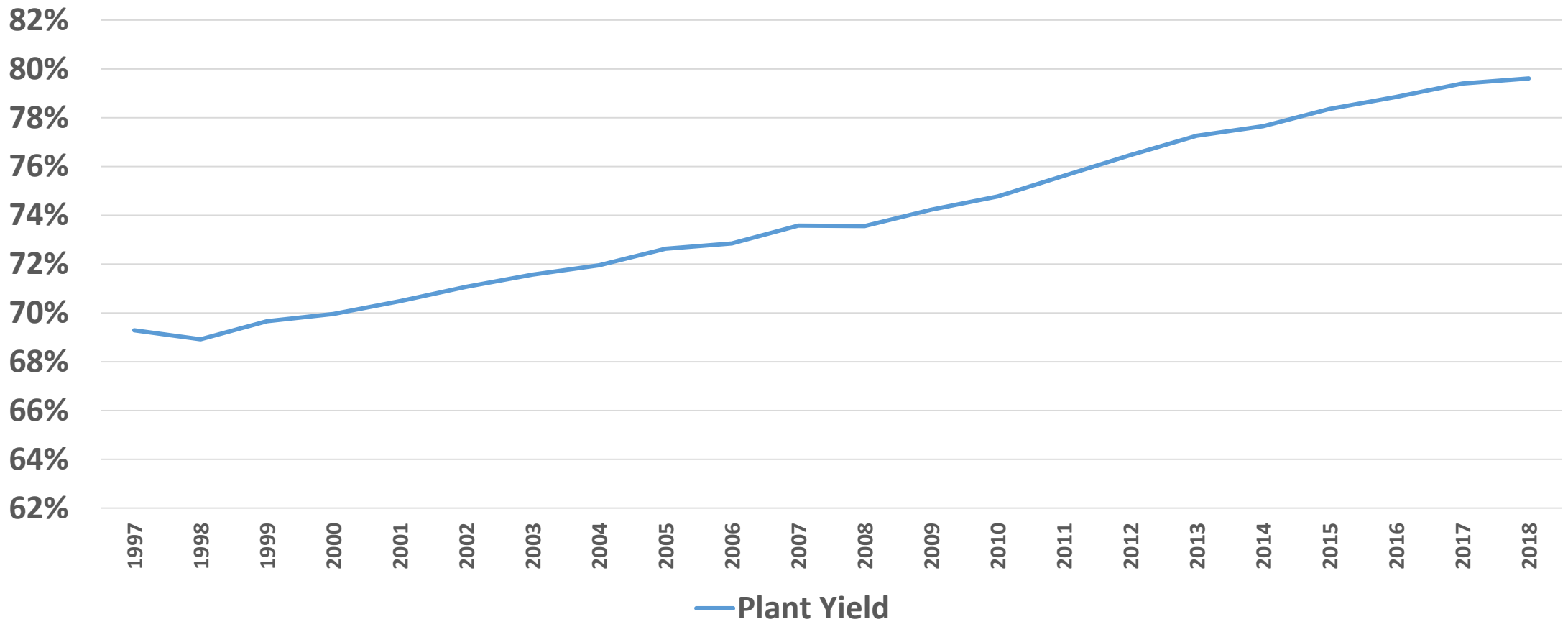
1988 to 2018

Mike Donohue
Agri Stats Inc
Fort Wayne, Indiana

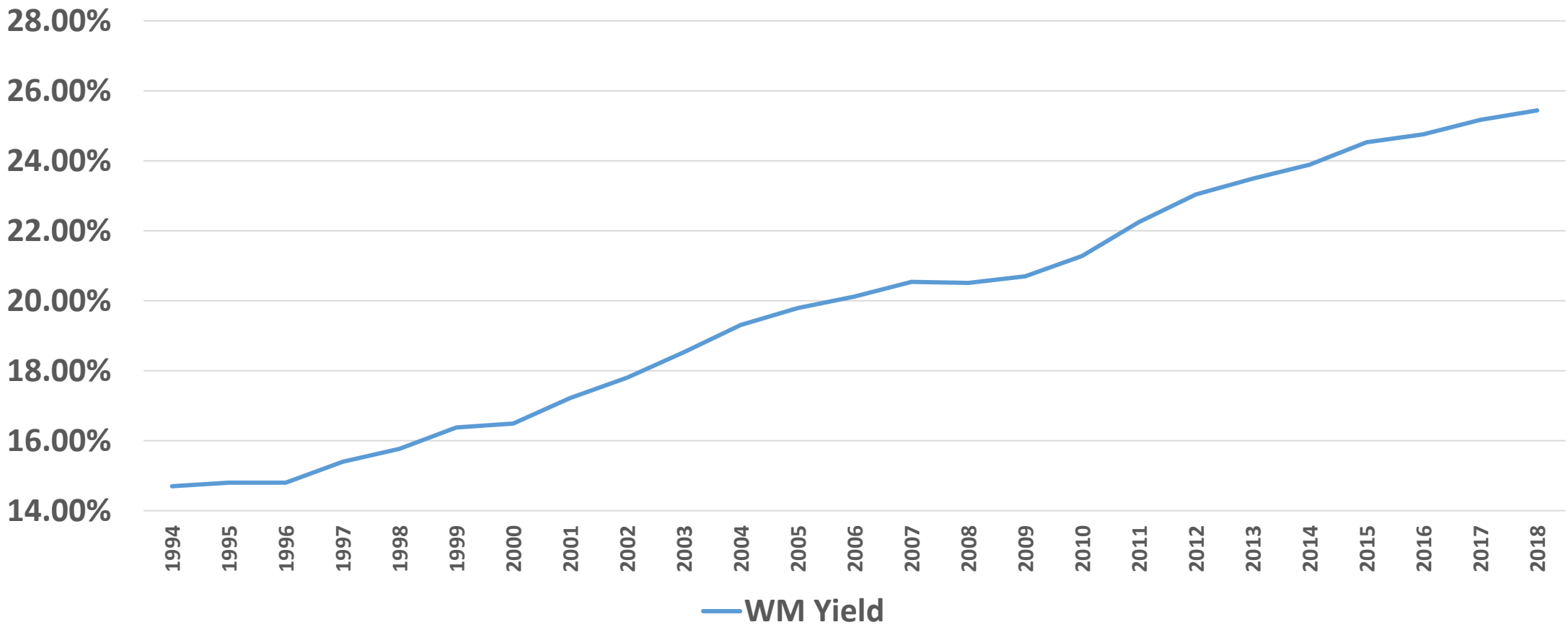
DAYS AND CALORIES TO 5.0 LB. LIVE WT.
U.S. BROILER INDUSTRY 1992 THROUGH 2018



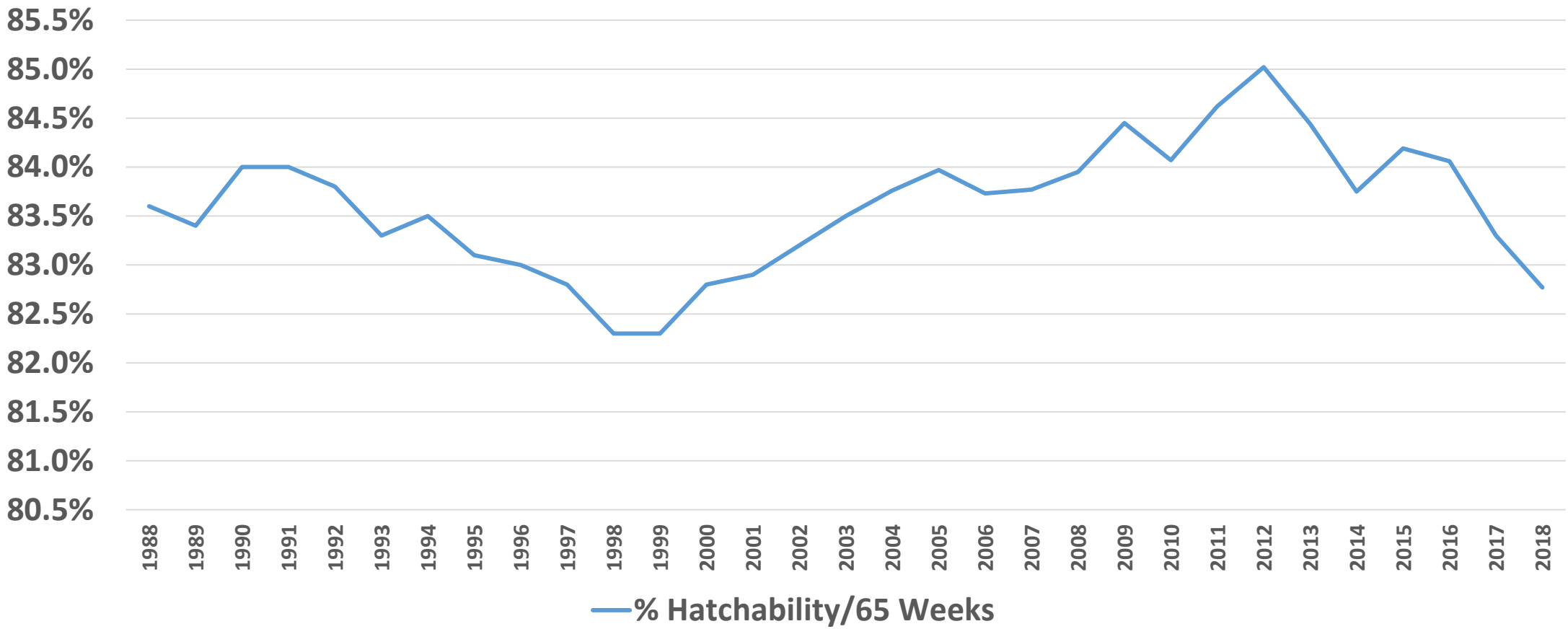
% WOG YIELD
U.S. BROILER INDUSTRY 1988 THROUGH 2018



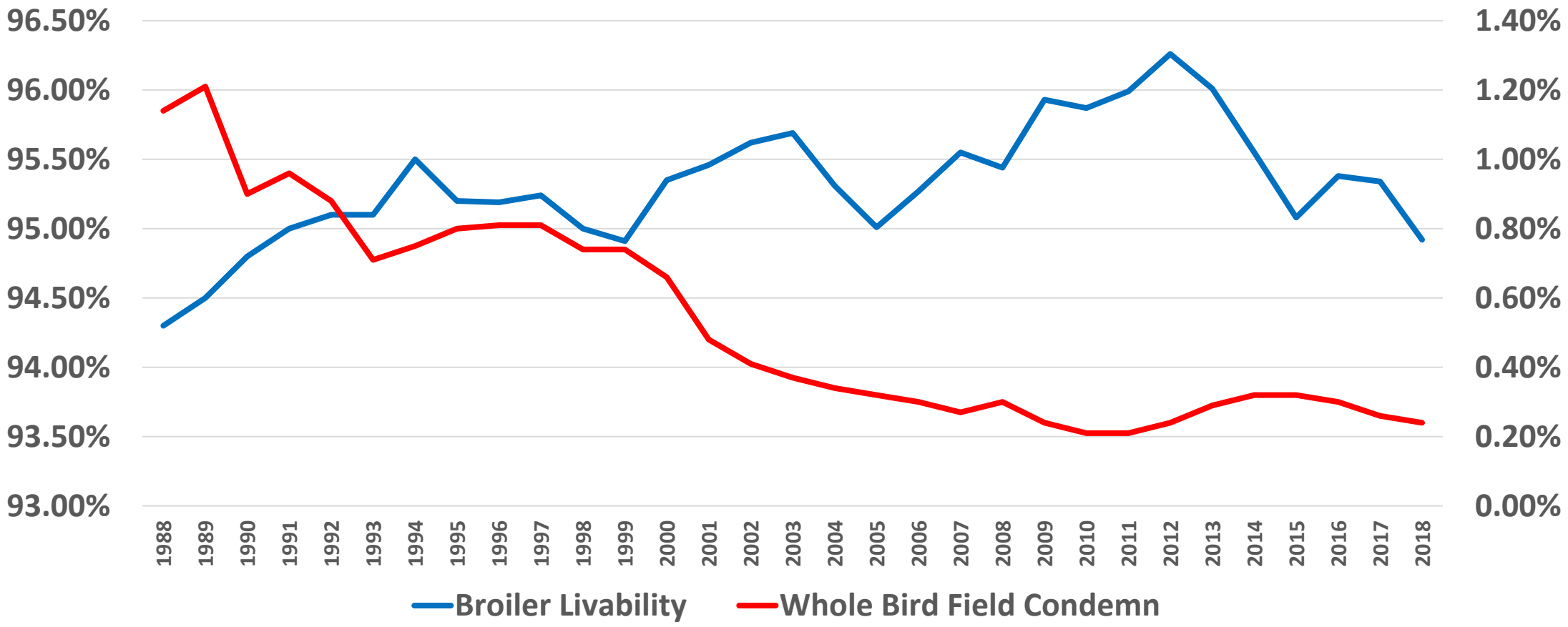
BONELESS BREAST MEAT YIELD (% OF LIVE WT.)
U.S. BROILER INDUSTRY 1988 THROUGH 2018



% HATCHABILITY (ADJ. TO 65 WEEKS OF AGE) U.S. BROILER BREEDER INDUSTRY 1988 THROUGH 2018



% BROILER LIVABILITY AND WHOLE BIRD FIELD CONDEMNATION
U.S. BROILER INDUSTRY 1988 THROUGH 2018



PROJECTING WITH AGRI STAT TRENDS

- In 2034----2.3 kg BW broiler will improve Calorie Conversion by 15% from present --Currently Require 5500 kcal ME/kg live wt---Decrease 42.2 feed kcal/yr/kg BW---Require 4867 kcal ME/kg BW in 15 yrs

- In 2034..Broiler livability will be 96.85%.....5% improvement each decade

- In 2034..Broiler boneless breast meat will increase to 26.2% of live wt……increase 0.5% of live wt/yr

PROJECTING WITH AGRI STAT TRENDS

- In 2034----2.3 kg BW at 28.75 days—reduce .56 d/yr
- Benefits of selecting broilers for faster growth rate is improved feed efficiency
- Sooner broilers get to desired market size, higher the percentage of feed consumed goes to lean mass instead of body maintenance
- Feed conversion declines as broilers get older because more feed consumed goes to maintenance

PROGRESS IN BROILER SELECTION: BENEFITS, LIMITATIONS AS ASSESSED BY THE DIGESTIVE FUNCTION, AND CONSEQUENCE ON DIETARY LYSINE CONCENTRATIONS

XIV EUROPEAN POULTRY CONFERENCE, STAVANGER, NORWAY, JUNE 2014

Bernard Carré
INRA, France

A model for feed intake calculation, set from literature data (42 publications)

Known values

- Age
- Body weight
- Daily growth
- Feed composition (requirement adjusted)

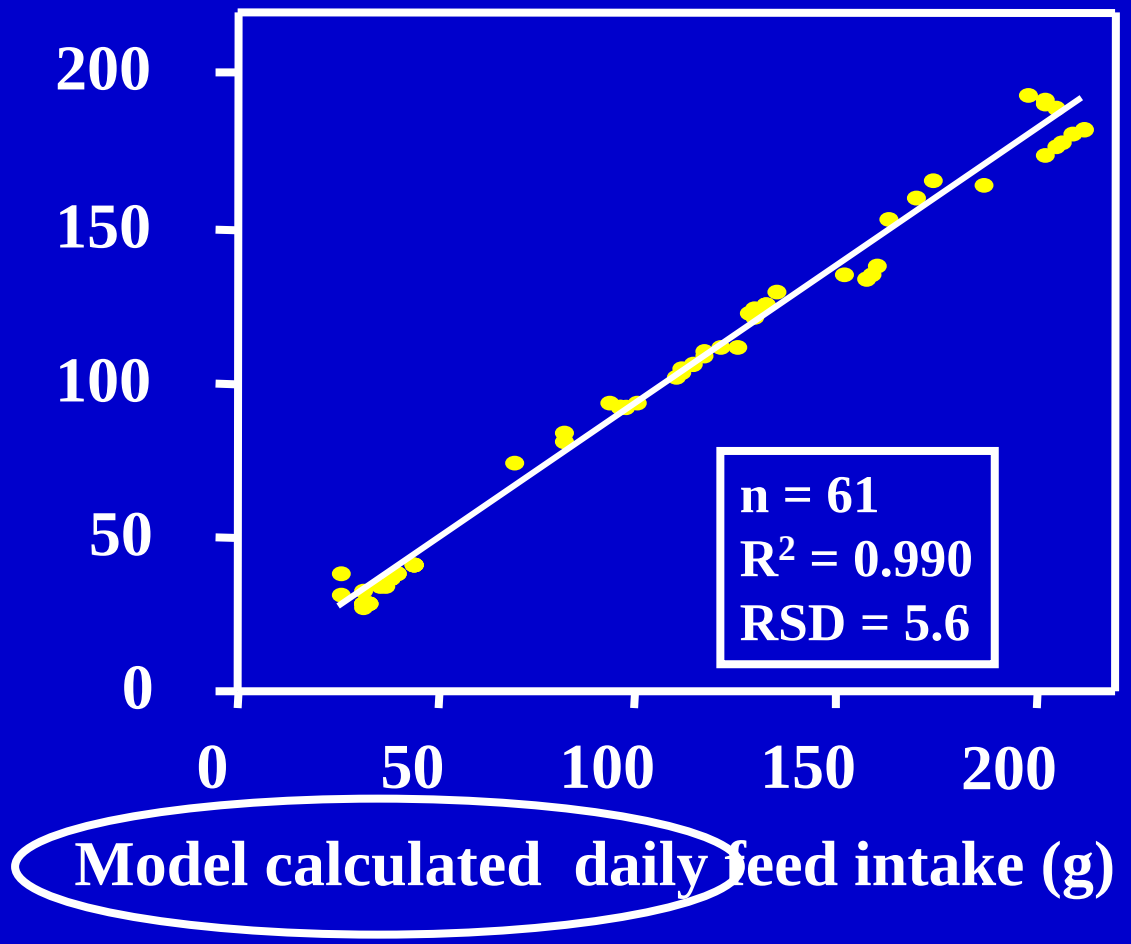
Model

Calculated values

- Daily feed intake

Carré et al., 2014. 14th European Poultry Conference, Stavanger (Norway)

Measured daily feed intake (g) in Ross broilers*



* Delezie *et al.*, 2012; Serrano *et al.*, 2012; Hashemipour *et al.*, 2013; van der Hoeven-Hangoor *et al.*, 2013 and Kim *et al.*, 2013

Carré et al., 2014.

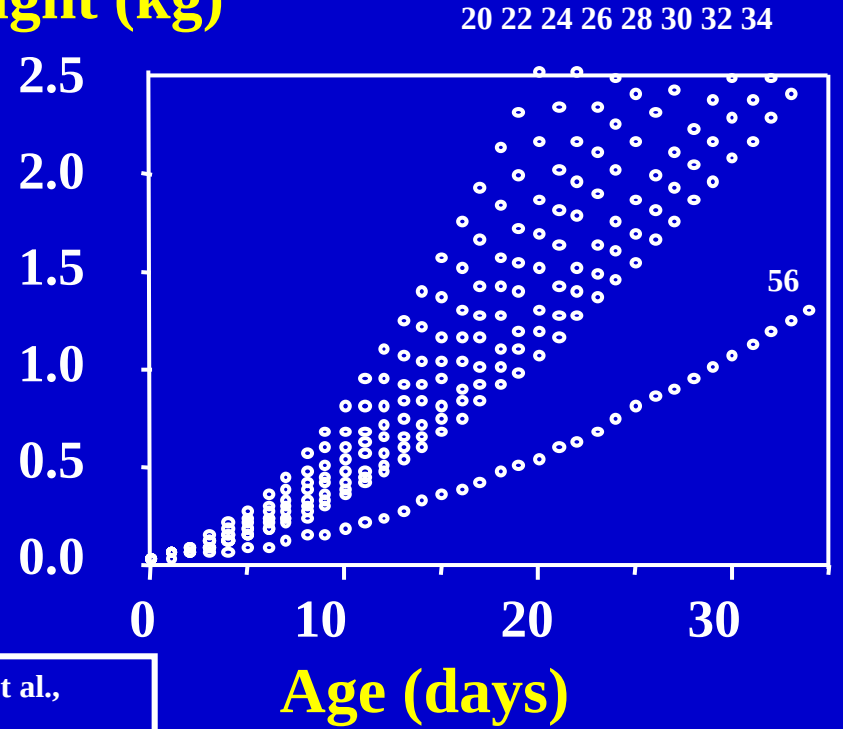
INRA

Model computations

Growth curves associated with different age at slaughter (2.5 kg)

2.5 kg Slaughter day

Body weight (kg)

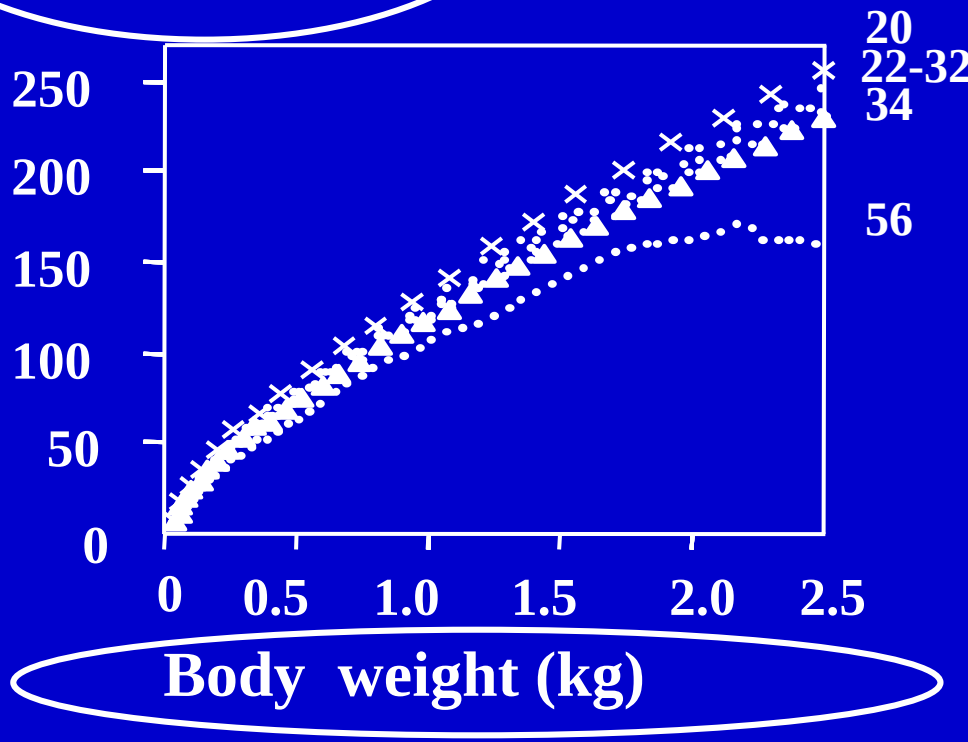


Carré et al., 2014.

Model

Calculated daily feed intake (g)

2.5 kg slaughter day



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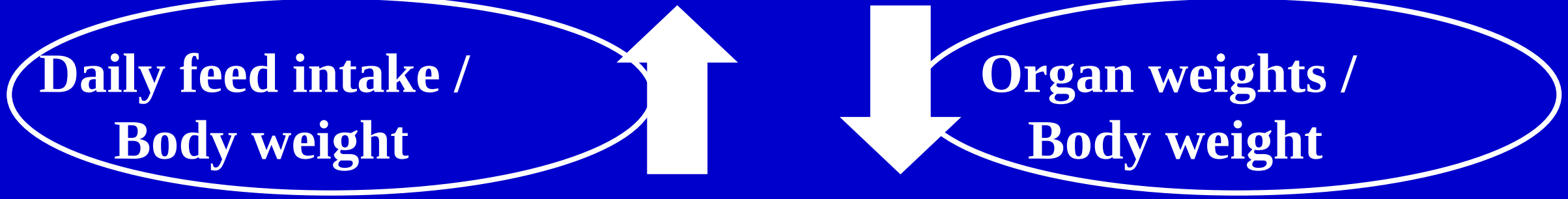
Evolution of broilers



Opposite directions

Difficult challenge

Slow increase in the challenge

Carré et al., 2014.
14th European Poultry Conference,
Stavanger (Norway)

Carré et al., 2014.

INRA

Predicting FCR and Protein Efficiency

2.5 kg slaughter day	FCR	Protein efficiency
20	0.98	0.607
22	1.05	0.604
24	1.13	0.608
26	1.20	0.606
28	1.27	0.606
30	1.35	0.607
32	1.41	0.604
34	1.48	0.602
56	2.22	0.540

Carre, 2014

Predicting DFI and % Digestible Lysine

$$DFI\ (g) = a BW^{j} (kg)$$

2.5 kg slaughter day	a	j
20	134	0.68
22	132	0.69
24	130	0.70
26	128	0.71
28	126	0.71
30	123	0.72
32	122	0.72
34	120	0.72
56	103	0.69

Digestible lysine recommendations (feed %)

2.5 kg slaughter day	Start.	Grow.	Finish.
20	1.60	1.59	1.38
22	1.53	1.49	1.34
24	1.47	1.44	1.23
26	1.42	1.39	1.18
28	1.38	1.36	1.13
30	1.32	1.30	1.08
32	1.29	1.27	1.03
34	1.26	1.23	1.00
56	1.07	0.99	0.73

Carre, 2014

Model computations

Consequences of one day gained (from 34 to 20 days) in the rearing period for a 2.5 kg slaughter weight

Feed / Gain :	- 0.034 or - 2.7 %
Protein gain / Protein intake :	+ 0 %
Dig. Lysine feed concentration : (grower diet)	+ 0.26 g/kg or + 2.0 %
Dig. Lysine feed concentration : (finisher diet)	+ 0.27 g/kg or + 2.7 %

Carré et al., 2014.

INRA

COMPARATIVE RESPONSE OF DIFFERENT BROILER GENOTYPES TO DIETARY NUTRIENT LEVELS

Franco Mussini
Dupont Inc.

Jejunum length (49 days)

Table 10. Jejunum length and ratio to BW at 49 d

Strain	Body weight(g)	Jejunum length (cm)	Jejunum (g BW/cm)
Ross 308	3768.33^{a}	90.88^{a}	41.64^{b}
Ross 708	3642.78^{a}	85.77^{ab}	42.70^{b}
Ross TY	3732.78^{a}	81.33^{b}	46.09^{a}
Heritage	1767.22^{b}	67.33^{c}	26.37^{c}
Prob > F	<.0001	<.0001	<.0001

Villus length (28 d)

Table 14. Villus morphometry by strain

Strain	Villus length (µm)	Villus width (µm)
308	1574[ab]	231
708	1637[a]	176
TY	1705[a]	203
HER	1484[b]	146
Prob > F	0.0112	0.471

Tibia diameter and breaking strength

Table 16. BW and tibia diameter and breaking strength

Strain	BW (g)	Diameter (mm)	Breaking strength (Kg/mm)	Age
Ross TY	2201.25[a]	8.002[b]	38.185[a]	35 days
Heritage	1767.22[b]	9.555[a]	23.313[b]	49 days
Prob > F	<.0001	0.0041	0.0008	
SEM	61.9	0.294	2.531	

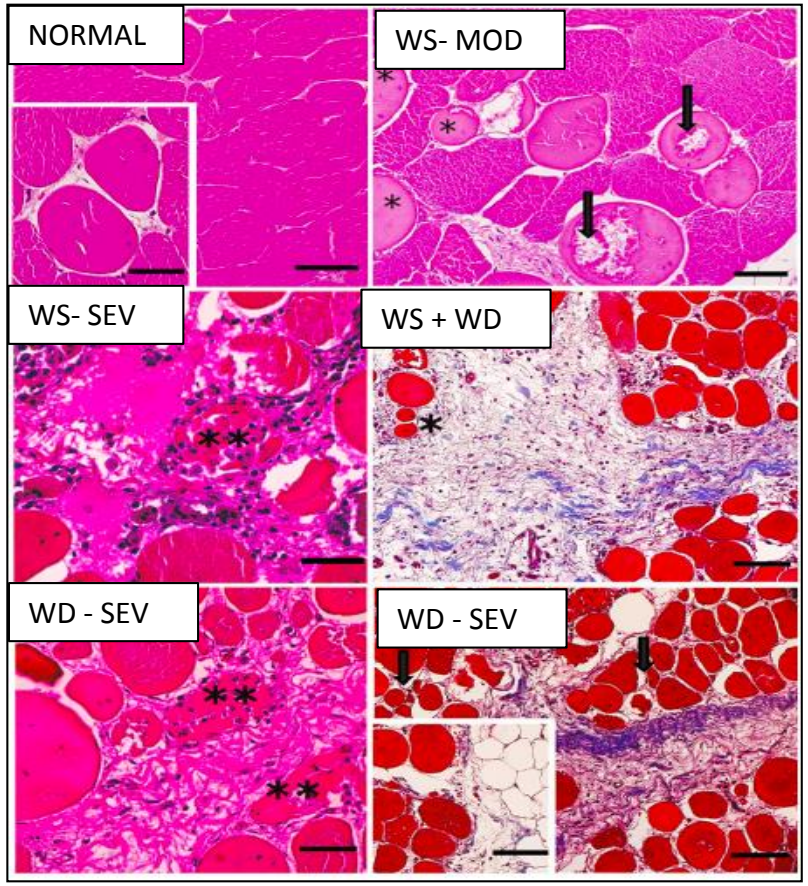
Atlantic Poultry Conference
2018

White Striping and Woody Breast in the Broiler Meat Industry

Casey M. Owens, Ph.D.
University of Arkansas

Breast Myopathies

- Recent: growth related myopathies
- Myopathies show histological lesions
  - Fiber degeneration, fibrosis, lipid infiltration, inflammatory cells, etc.
- *Mazzoni et al. (2015) reported that all breast from heavy broilers had histological lesions, but % of fibers affected varies*
  - >20% fibers show degeneration in severe cases
- White striping and Woody Breast



Kuttappan et al., 2013 Sihvo et al., 2014;
Trocino et al., 2015; de Brot et al., 2016

Economic Losses

- Condemnation
  - trim, whole fillet, or carcass!
- Decreased yield
  - Drip loss, Cook loss, Marinade retention
- Decreased value (downgrades)
- Adding and training personnel for grading/sorting
- Lost business?

$200 million

USD, Annually, conservative

Kuttappan et al., 2016

Breast Myopathies/Meat Quality

Industry Concerns?

YES!

Why?

- Quality defect at high incidence
- Downgrades/Condemns
- Customer (restaurants) complaints
- Consumer awareness
- Economic losses

UNITED STATES DEPARTMENT OF AGRICULTURE
FOOD SAFETY AND INSPECTION SERVICE
WASHINGTON, DC

FSIS NOTICE	35-17	7/5/17

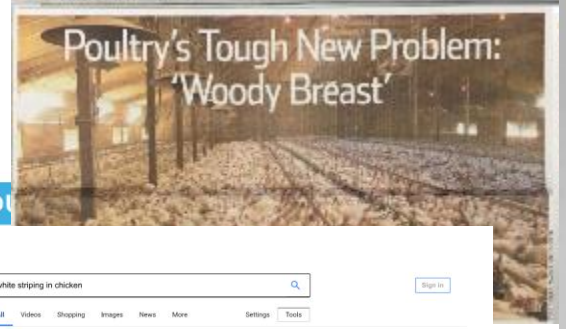
DISPOSITION INSTRUCTIONS FOR "WOODY BREAST" AND "WHITE STRIPING" POULTRY CONDITIONS

I. PURPOSE

This notice provides disposition information for conditions occurring in the breast muscles of broiler chickens referred to as "Woody Breast or "White Striping." Upon issuance of this notice, Public Health Veterinarians (PHVs), Inspectors-in-Charge (IICs), Front Line Supervisors (FLSs), and Supervisory Consumer Safety Inspectors (SCSIs) as appropriate are to correlate with inspection program personnel (IPP) on how to identify and verify that poultry establishments are removing trimmable inflammatory tissues that may be associated with these conditions.

The picture below shows a thick, gelatinous fluid, yellow in color on the left side of this picture. On the right side there are several very small hemorrhages in a cluster. There is an overall shiny surface indicating excess fluid in the tissues. These associated inflammatory tissues require trimming.

In the Media…..



MEAT+POULTRY

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- Keith Nunes
- Richard Alaniz
- Dr. Temple Grandin
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FREE WEBINAR
ADVANCES IN KILL FLOOR TECHNOLOGY

Mysterious myopathy

SEPT. 27, 2016 - BY KIMBERLIE CLYMA

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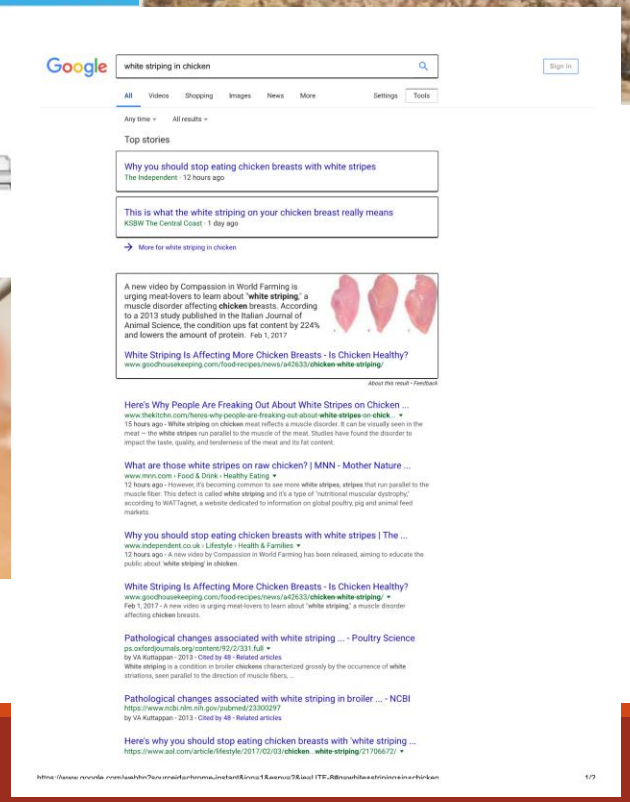
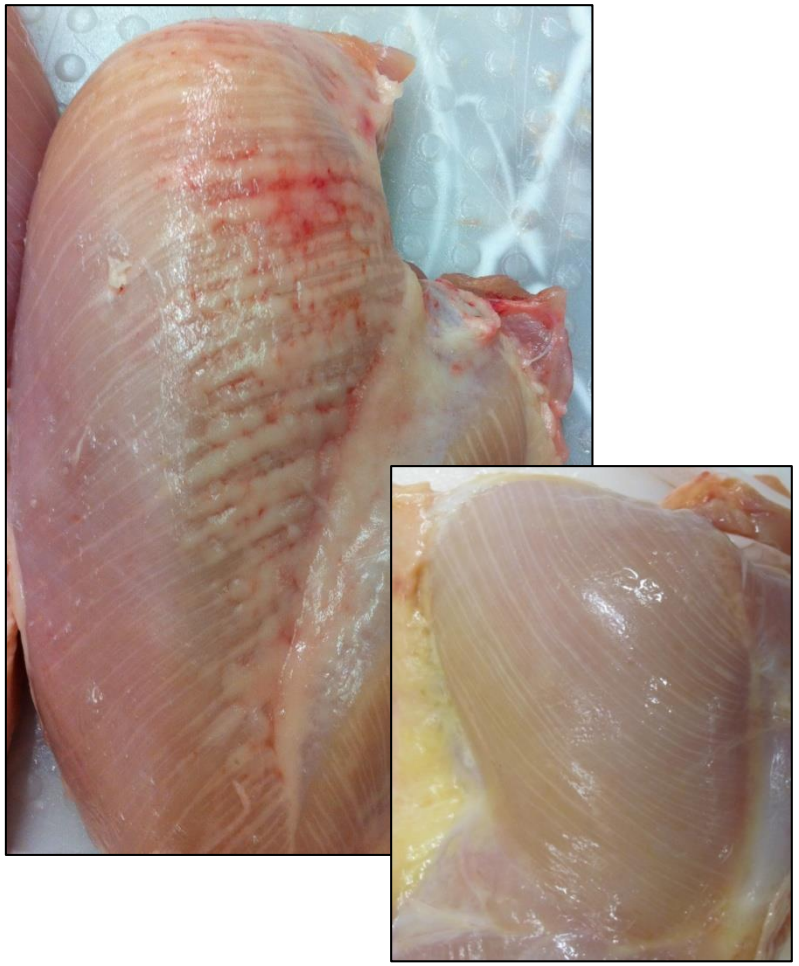
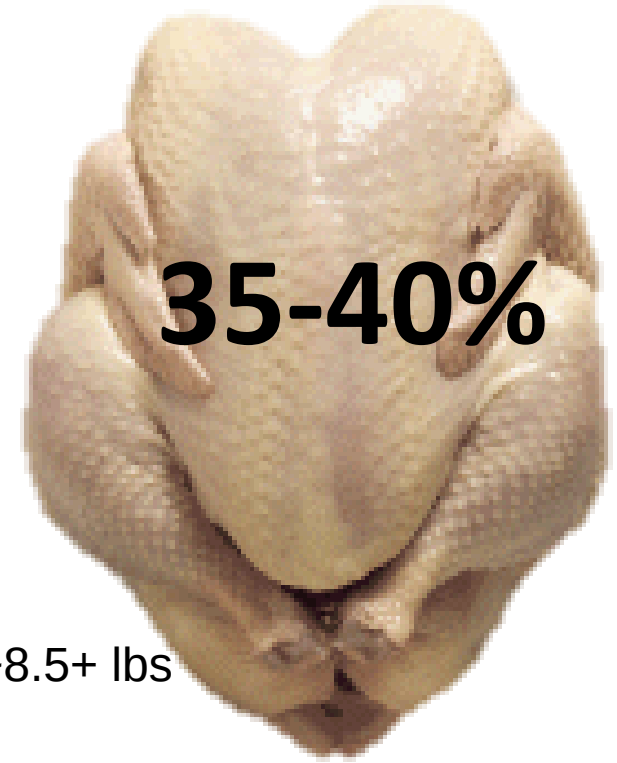


White Striations

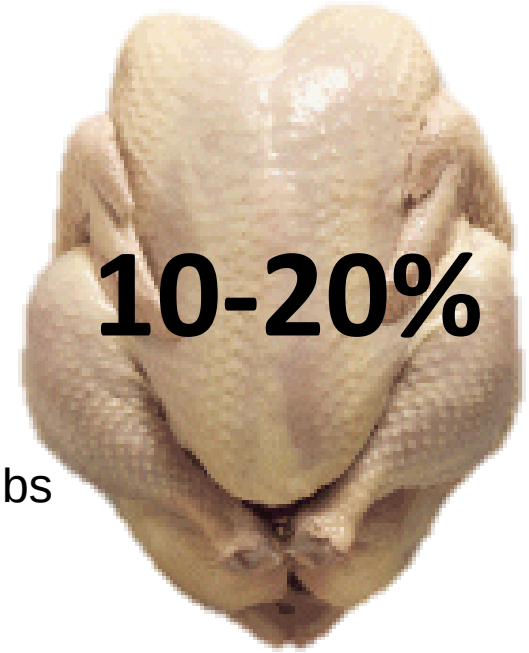
- White striping is the occurrence of varying degrees of white striations
- Commonly seen on breast fillets and thighs
- An emerging tissue in broiler meat industry
  - Global markets



Incidence of SEVERE WS in Commercial Plants

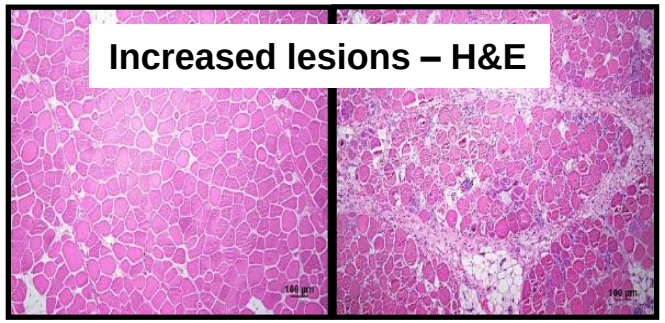


~8.5+ lbs

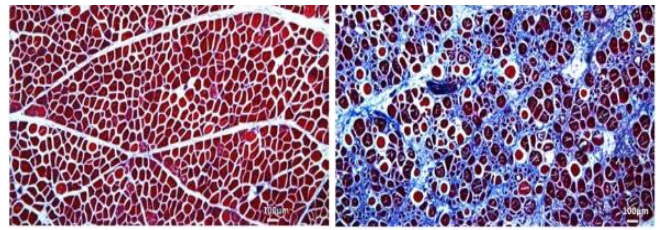


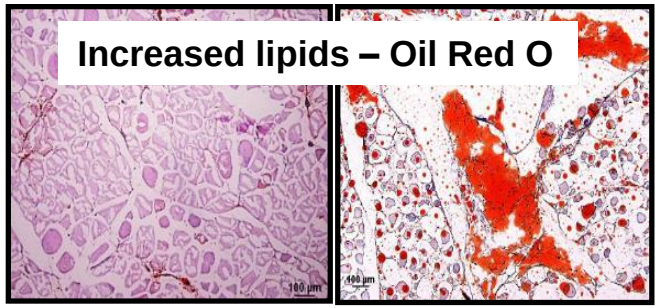
~7 lbs

Multiple plants, strains



Increased fibrosis – Masson's Trichrome



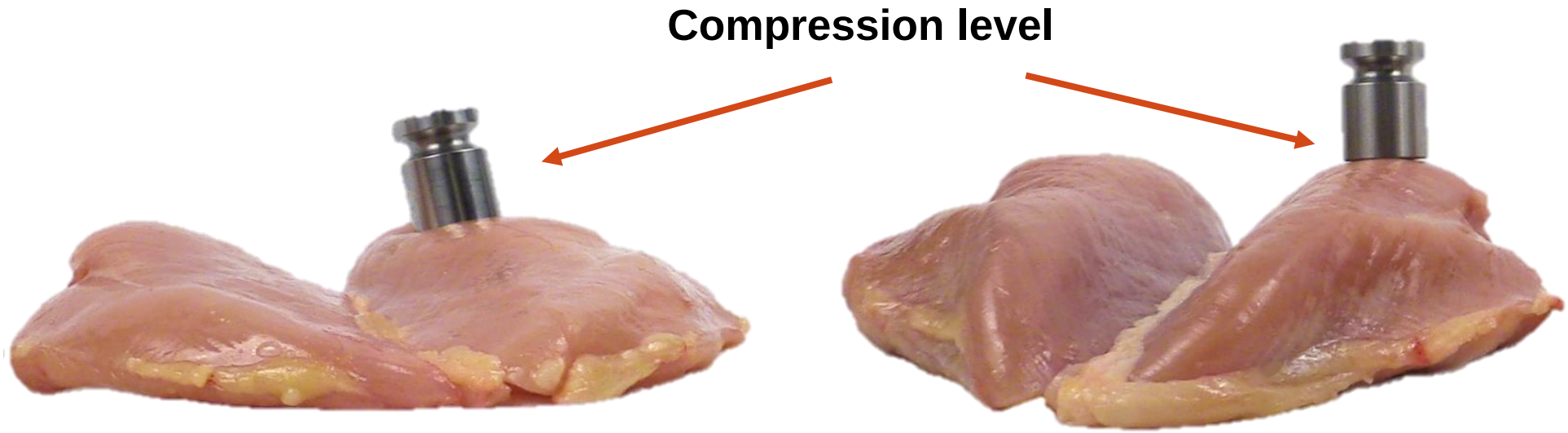


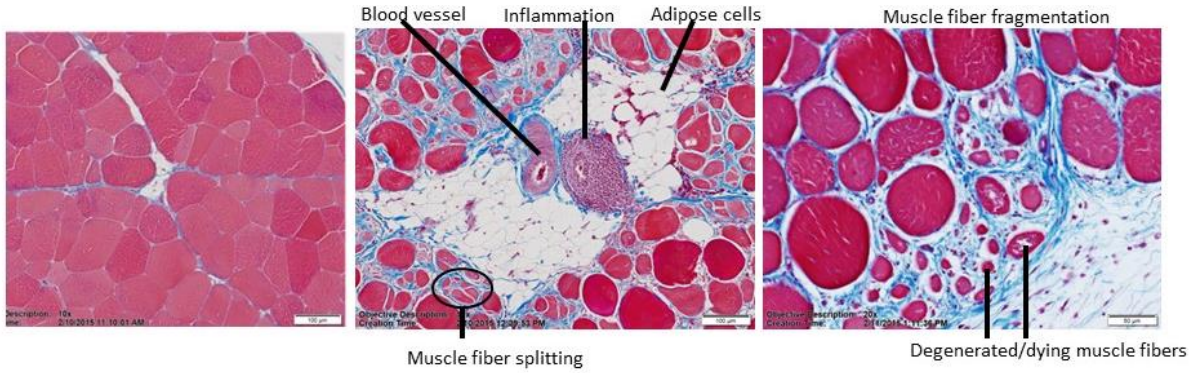
Composition:
- **Increased Fat**
- **Decreased Protein**

- **Increased protein breakdown**
- **Increased expression of proteolytic genes (Murf-1, Atrogin-1)**

Kuttappan et al., 2013
Vignale et al., 2016

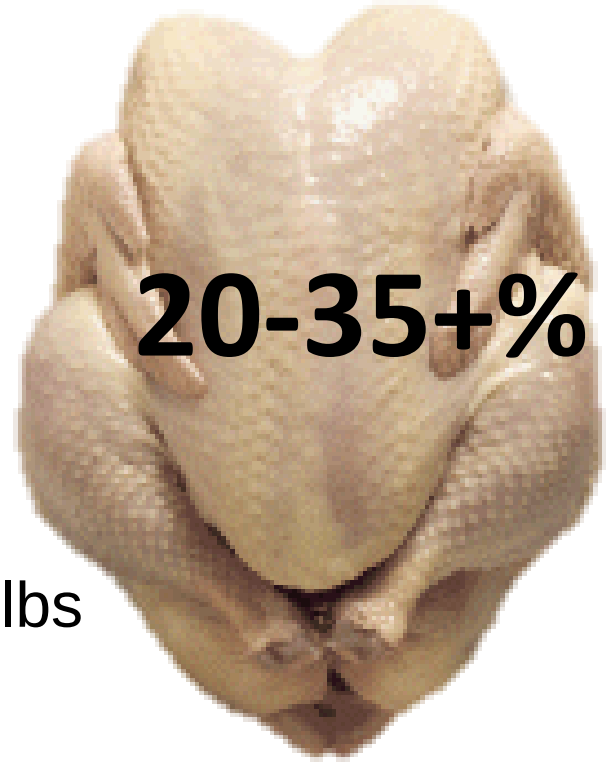
Wooden “Woody” Breast



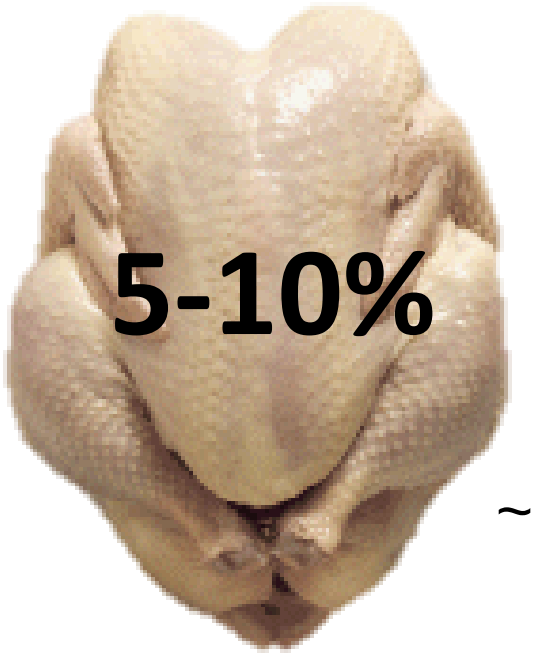


Kuttappan et al., 2016

Incidence of MODERATE and SEVERE WB in Commercial Plants



~8.5+ lbs



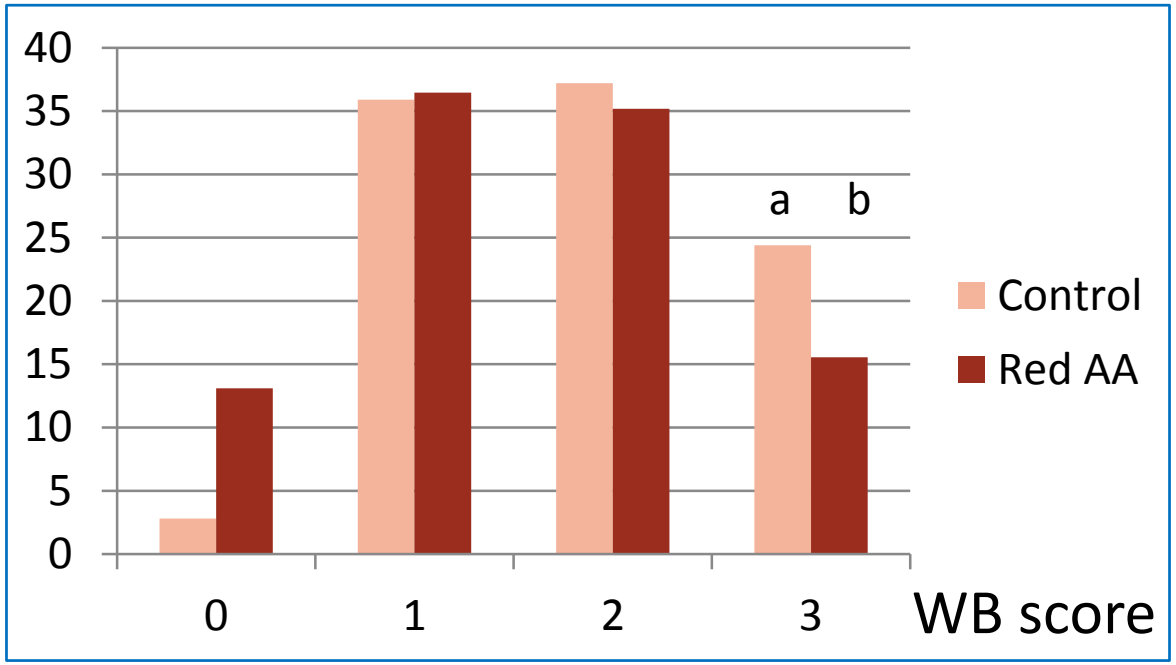
~7 lbs

2016-2017
Multiple plants, strains
High yielding strains > Standard yielding

How to Manage Woody Breast in Short Term: Live Production

- Nutritional modification
  - Recommendation: Reduced lysine in growout (12-24d)

✓ Reduced (15%) amino acids
✓ Reduced severity of WB
✓ No change in FCR
✓ Improved breast meat value when accounting for WB



Lee and Alvarado, 2017

Development of the ARK* NE system

K.M. Hilton, A. Beitia, J. T Weil, N. Suesuttajit , P. Maharjan and C.N. Coon

University of Arkansas, Center of Excellence for Poultry Science, Fayetteville, Arkansas

UNIVERSITY OF ARKANSAS
DALE BUMPERS COLLEGE OF AGRICULTURAL, FOOD & LIFE SCIENCES
1871

UNIVERSITY OF ARKANSAS

100 %

* 4400 Kcal/Kg

Gross Energy

Energy loss FAECES

3400 Kcal/Kg

Apparently Digestible Energy

77%

Energy loss URINE

3200 Kcal/Kg

Metabolizable Energy

73%

Heat Increment

2800 - 1800 Kcal/Kg

Net Energy

53%

CALORIMETRY

33 %

Net Energy Gain

Net Energy Maintenance

*Energy values are from Morris and Freeman, 1974

Adapted from Farrell, 1974

INTRODUCTION

- Utilizing a NE system will further enhance efficiency and profitability (Wu, et. al. 2018)
  - More accurate way to formulate to energy needs reducing over and under formulation
- Classic NE equations accounts for no information about type of body composition
  - Fat gain vs. protein gain

CLASSIC NE EQUATION:

NE (kcal/kg) = AME intake – HI*

***HI=Heat Increment**

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ARK NE EQUATION*:

NE (kcal/kg) = NEg + NEm

Body Composition

HP

*patent applied for by the University of Arkansas System, Division of Agriculture

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Table 2. Comparison of Arkansas net energy value verse classic net energy value by line.

Line	AME	Classic NE	Arkansas NE Equation	kcal Difference	Classic NE/ME	Arkansas Equation NE/ME
	kcals	kcals/kg	kcals/kg	kcals/kg	%	%
A	3,137	2,460	3,498	1,038	78	111
B	3,137	2,379	3,325	946	75	105

Table 3. Experiment 1 results comparison by temperature.

Temperature	AME	Classic NE	Arkansas NE Equation	kcal Difference	Classic NE/ME	Arkansas Equation NE/ME
	kcals	kcals/kg	kcals/kg	kcals/kg	%	%
Cool	3,137	2,492	3,699[a]	1,207	79	117
Hot	3,137	2,347	3,124[b]	777	75	99
***p*-value**			*0.0180*			

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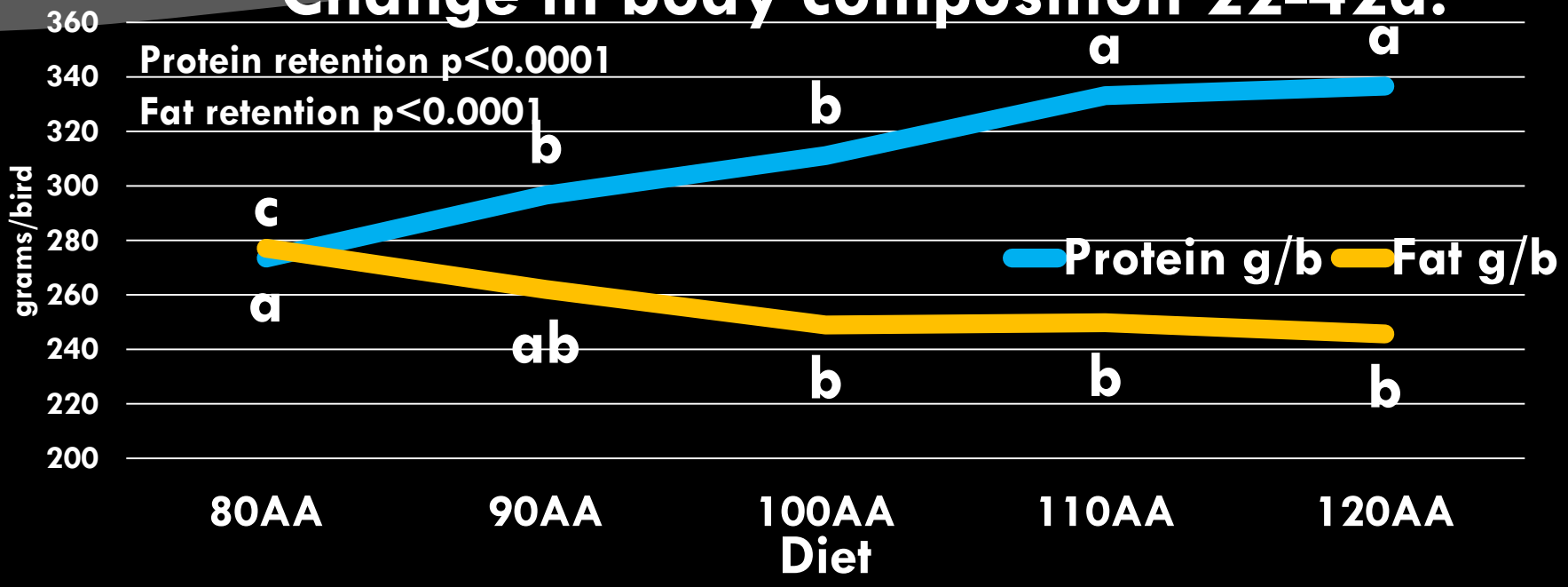
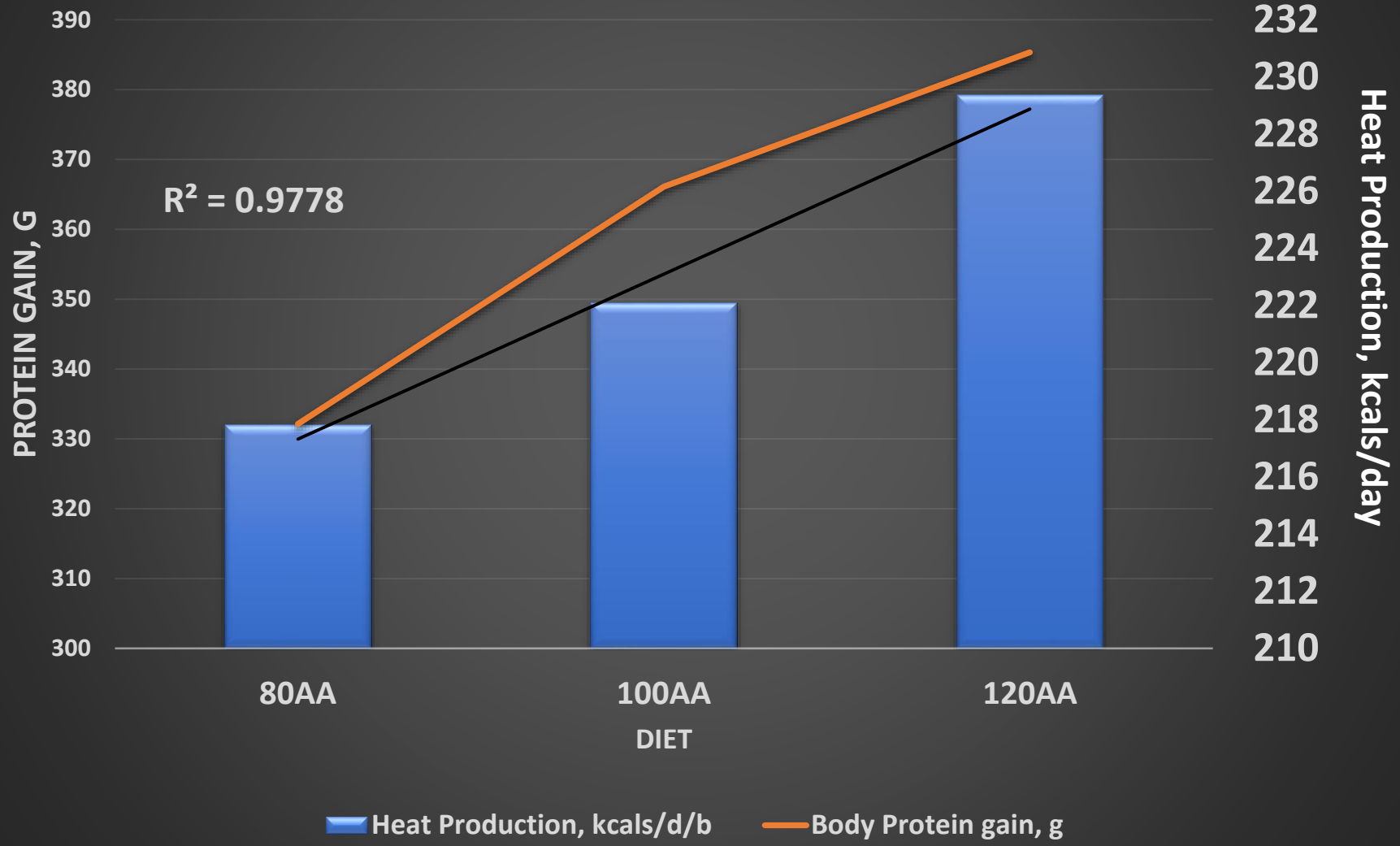
Change in body composition 22-42d.

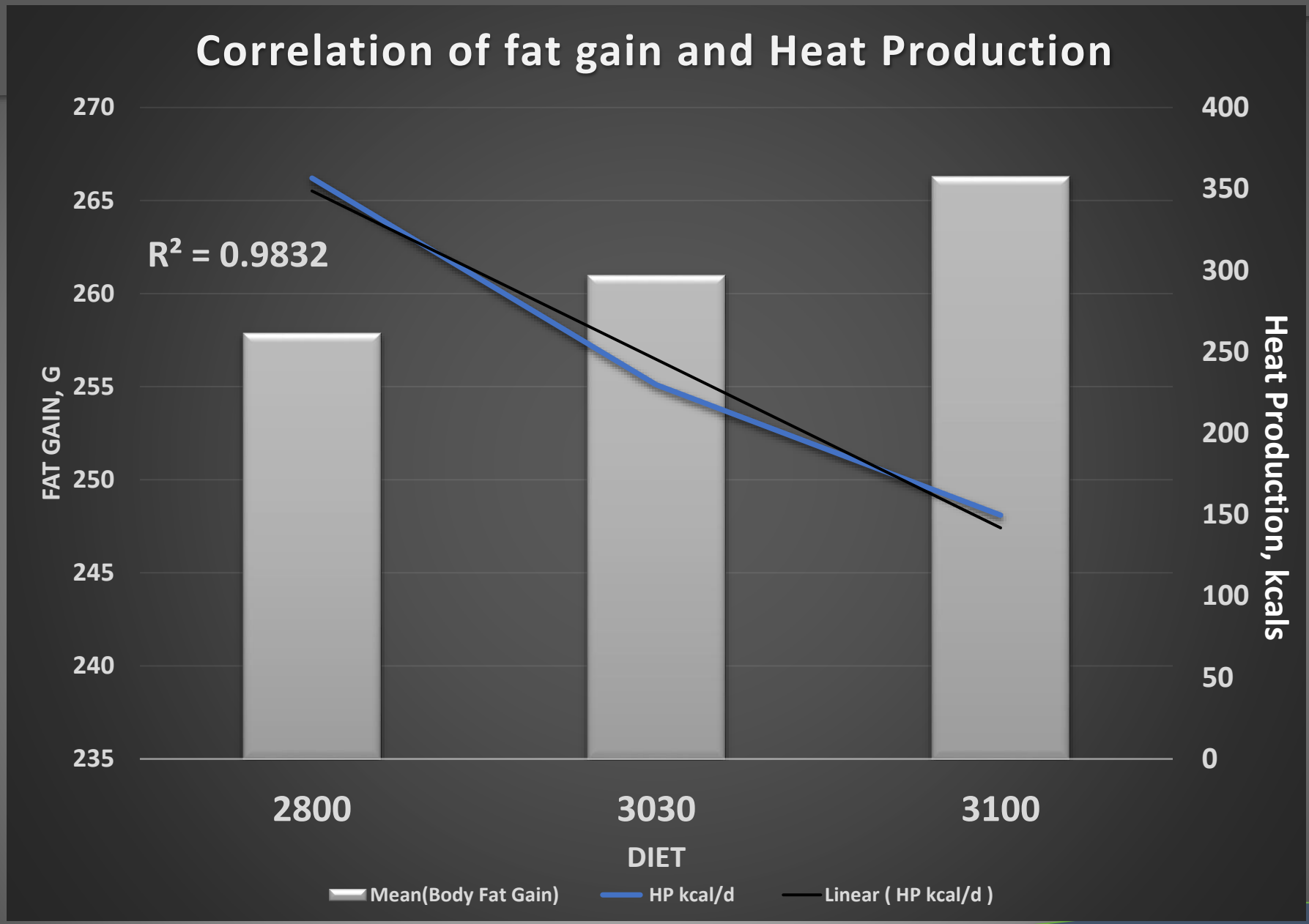


Amino Acid Level	ME	Classic NE	Ark NE Equation
%	*kcals*	*kcals/kg*	*kcals/kg*
80	3,137	2,476	3,128
100	3,137	2,423	3,557
120	3,137	2,359	3,550

Hilton et. al, Proc. 39(E-Suppl. 1):18 (Abstr.).

Correlation of protein gain and Heat Production





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COMMERCIAL LAYERS

Dr. Neil O'Sullivan
Hy-Line Genetics

Annualized Genetic Gain

Trait	Hy-Line Brown	Hy-Line W36
Age @ 50% Pr	0.6	0.7
Livability in Grow	0.1%	0.1%
Livability in Lay	0.2%	0.1%
HH Eggs	3.2	3.1
Body Weight @ 18wk	25g	15g
@ 32wk	15g	10g
@ 42wk	5g	5g
Feed Conversion	1.3%	1.2%
Out of Nest Eggs	-6.7%	-0.2%

Annualized Genetic Gain

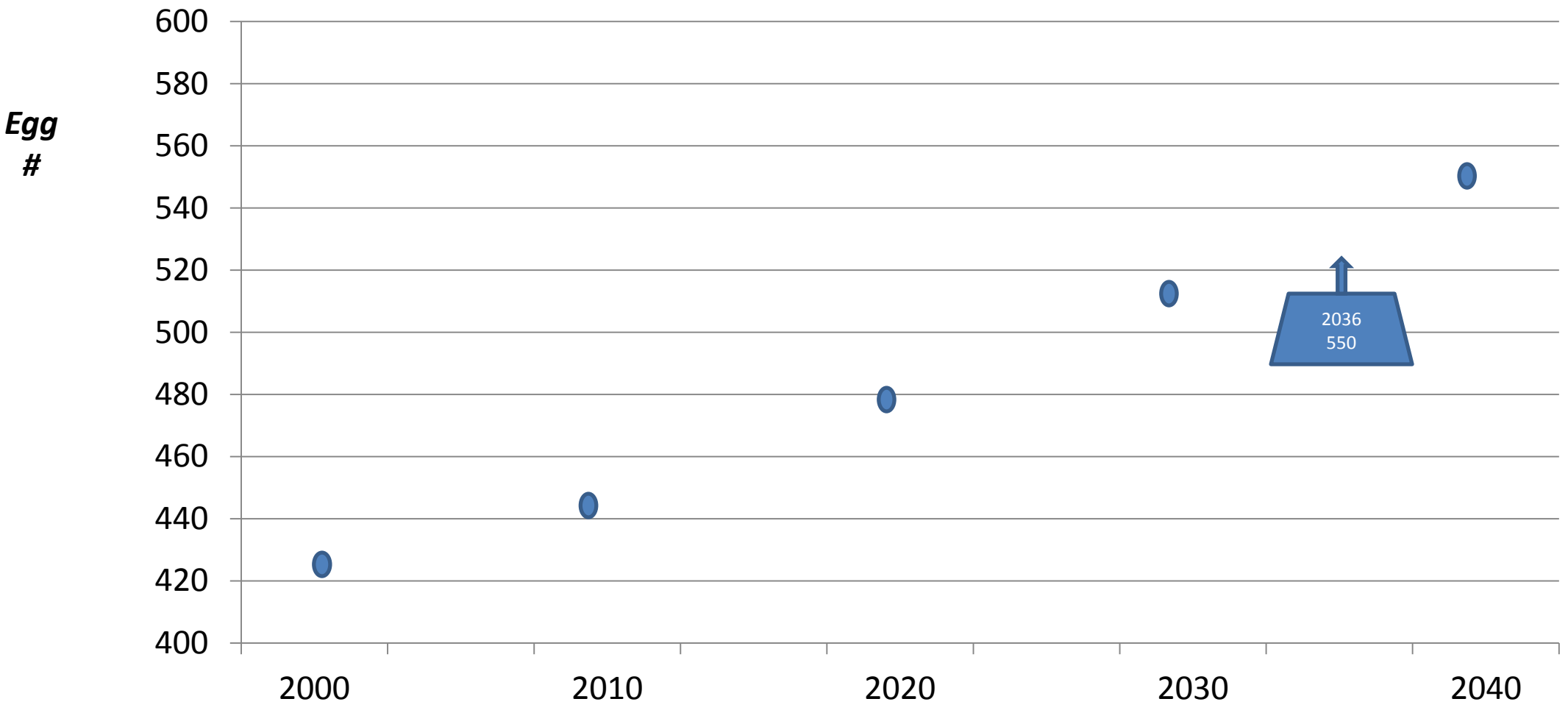
Trait	Hy-Line Brown	Hy-Line W36
Egg Weight - First	0.45g	0.40g
@ 26wk	0.30g	0.35g
@ 42wk	0.10g	0.10g
@ 60wk	0.00g	-0.01g
Yolk Weight @ 26 Wk	0.31g	0.19g
Shell Strength	6g	5g
Haugh Units	0.8	0.8

Layer Nutrition and Management Changes

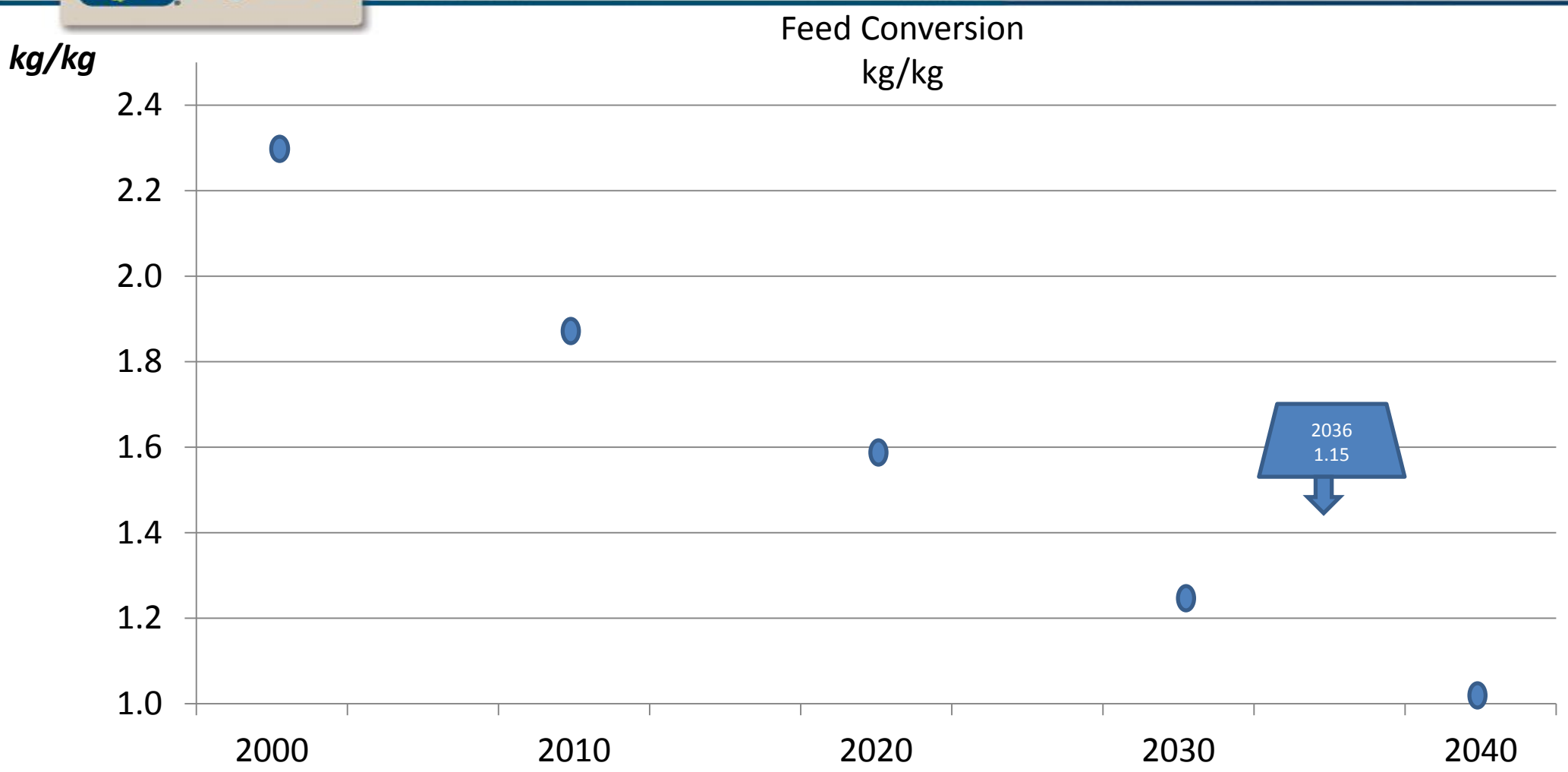
Single Cycle Production

Cage Free Production

100 Week Egg Number

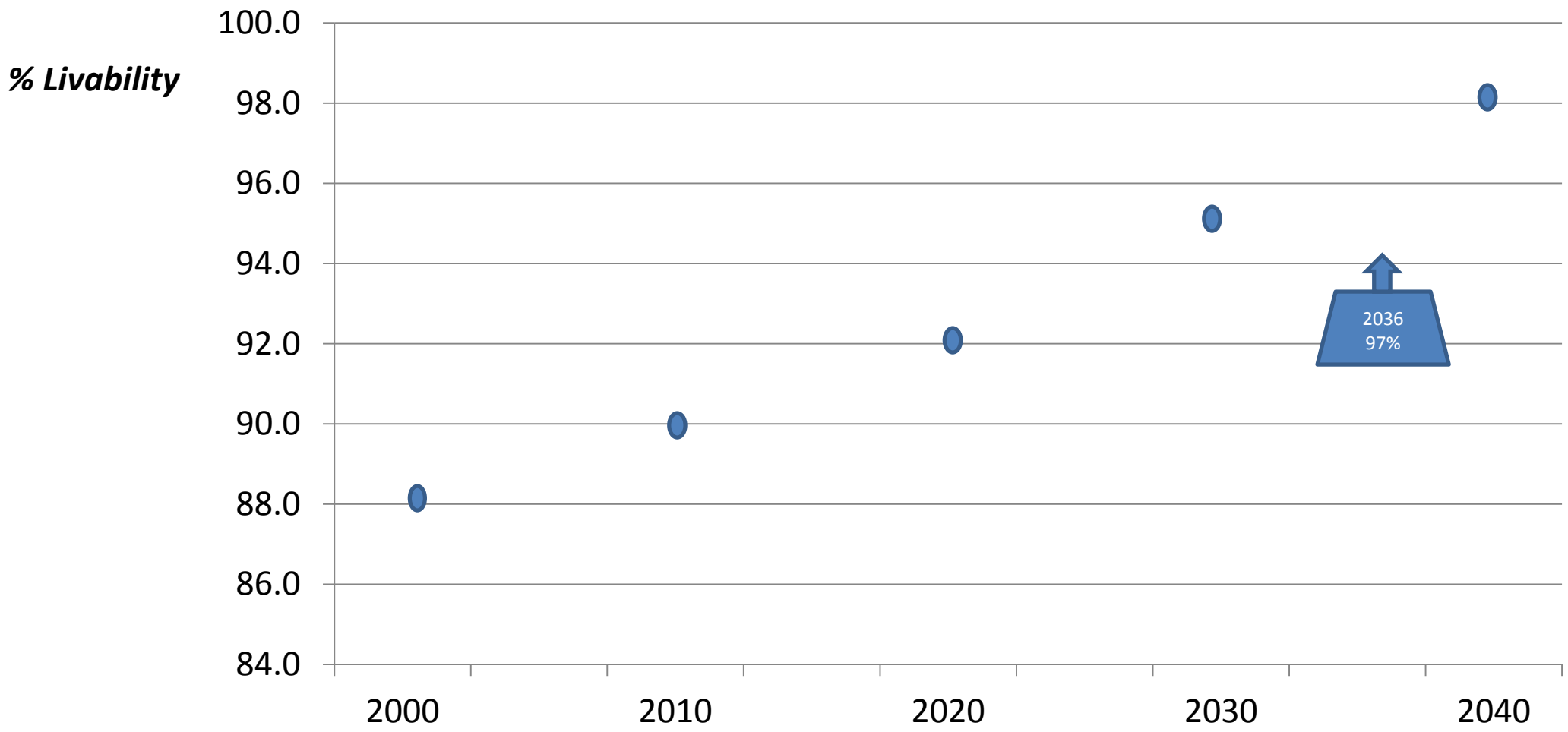


Hy-Line will celebrate 100 years with our hens laying 550 eggs to 100 weeks of age



Hy-Line will celebrate 100 years with our hens converting 1.15 kg feed into 1.0kg eggs to 100 weeks

100 Week Livability



Hy-Line will celebrate 100 years with our hens living at 97% to 100 weeks

Digitalization of the Feed Industry

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UPCOMING EVENTS

Seeds of Our Future: Innovating Global AgTech
August 27 - August 30

Crop Innovations and Regulations Conference

Report: Agriculture in Top 5 Most Automatable Industries, Above Retail

OCTOBER 24, 2017 EMMA COSGROVE

Agriculture is the least digitized of all major industries, according to the McKinsey Global Institute's Digitization Index. But a recent study by the same firm entitled "Human + Machine: A new era of automation in manufacturing," looked at agriculture's potential for automation and the results suggest that this has little to do with the fundamental tasks and activities that make up farming. The report set out to not only evaluate the

Ingredient vs. Nutrient Driven

“

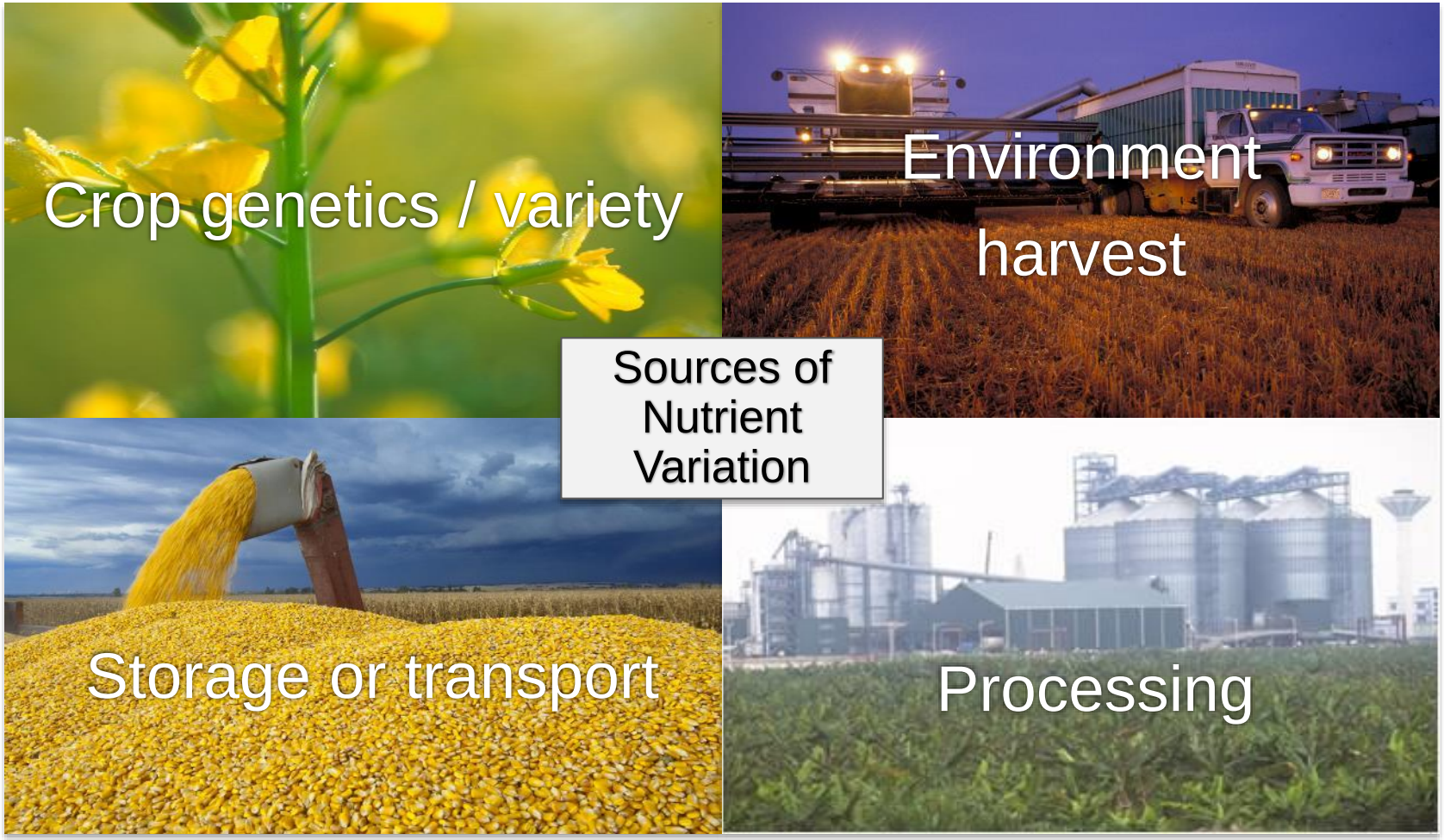
All nutrition boils down
to the simple concept of
Supply & Demand

More specifically:
Nutrient Supply and
Nutrient Demand

Ingredient Focus **Nutrient Focus**

Cargill®

Nutrient Variation is the Reality in Our Industry



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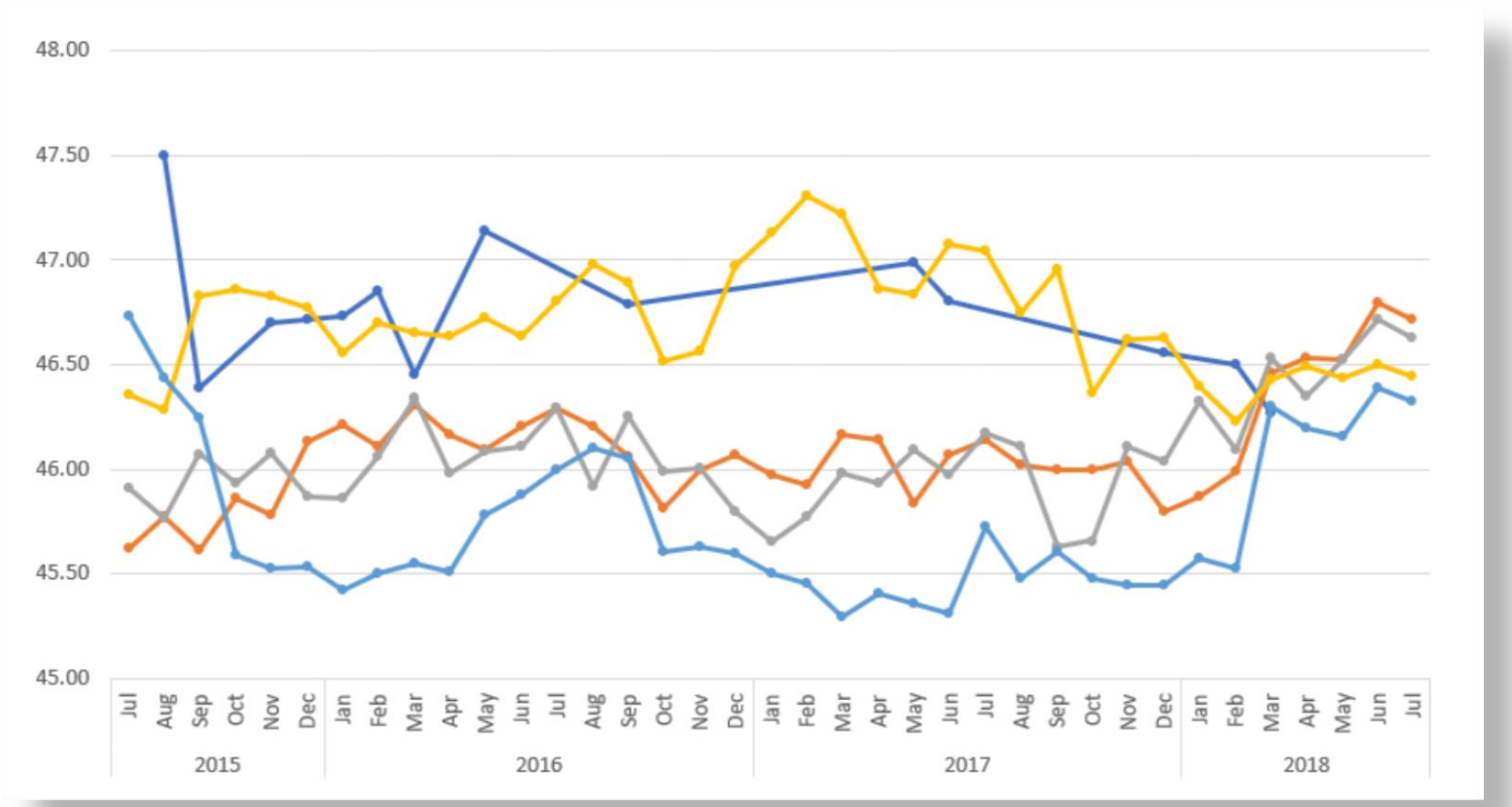
Soybean Meal Protein

Each line represents a major industry supplier of SBM and shows average protein levels over time

Crude Protein %



2.21% Spread, 4.88% Difference

Cargill

CONCLUSIONS

- Fastest Way to Select for Feed Efficiency is through rate of gain
- In 15 years –Industry will be marketing 2.3 kg broiler in 28 days
- Projected 2.5 kg broiler at 20 days will have a 1:1 FCR—Will happen in 2048/2049 at current increase in gain
- NE is more efficient use of calories than ME and should reflect protein gain
- Future conflicts ahead between digestive function and meat yield
- Continued conflicts ahead with regard to meat quality—white striping and woodie breast-short term answer is slow down rate of gain
- Egg industry is on target to continue reducing feed intake , increase egg mass out put and livability
- Egg industry is moving to single cycle production with less need to molt and also observing increased cage-free production

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