EXPANDING USE OF DISTILLERS PRODUCTS IN AQUACULTURE DIETS

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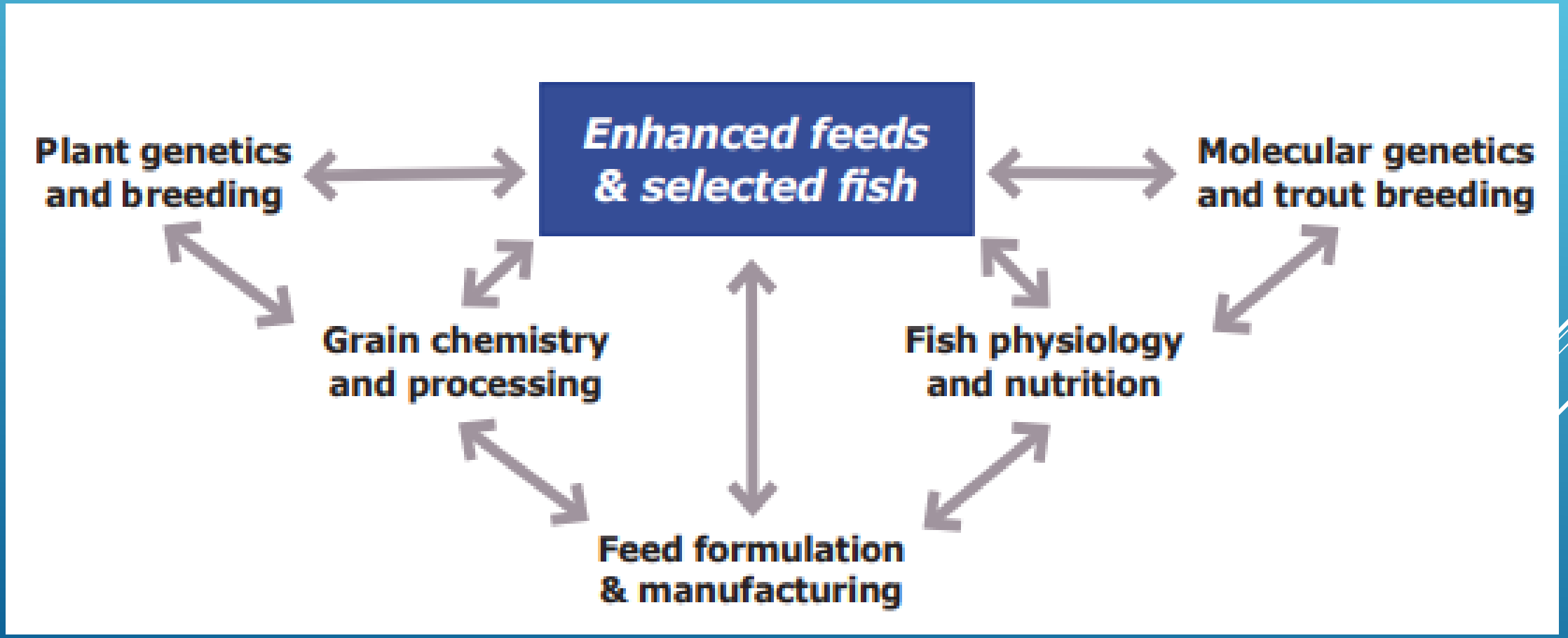
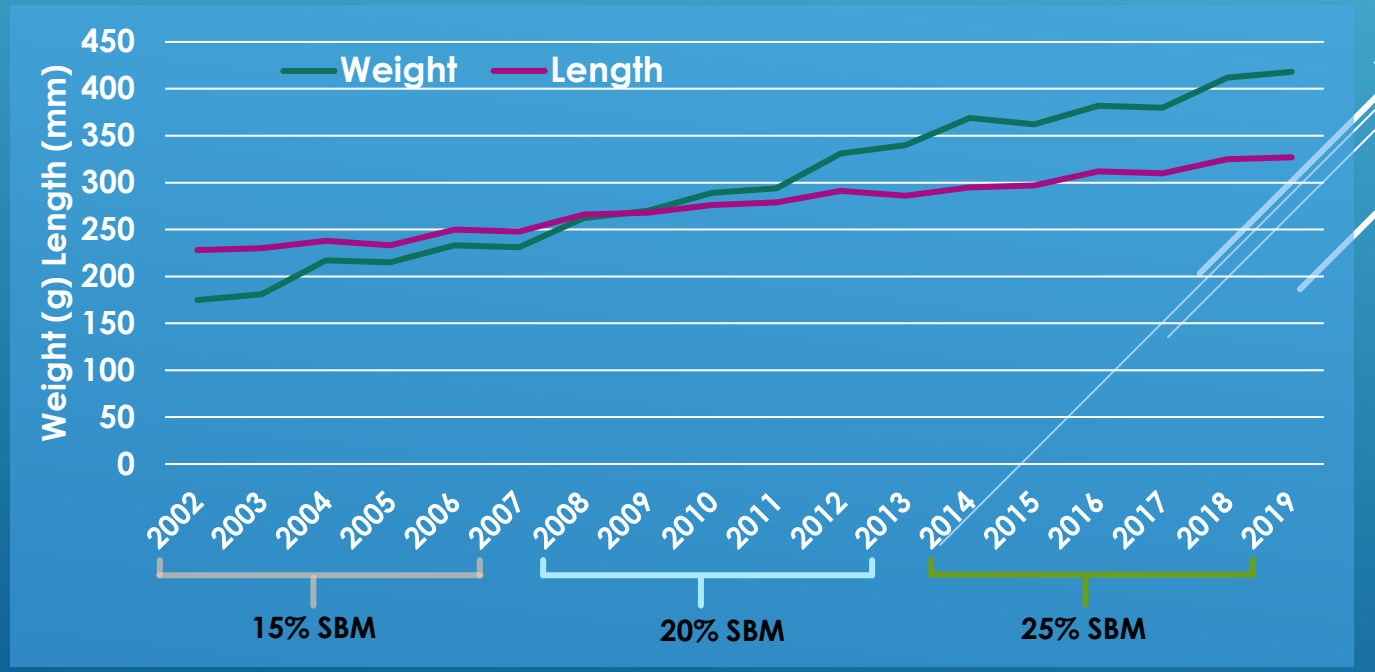
USDA ARS TROUT GRAINS PROGRAM



USDA ARS TROUT GRAINS PROGRAM

- Evaluate for improved performance when reared on a plant protein-based feed, without development of enteritis as seen in unselected strains of trout. Find changes linked to immunomodulation, amino acid transport, muscle accretion, and pathogen resistance.

Selection for Utilization of Sustainable Diets



Co-located offices:

- **Sub-office of USDA Research Services Trout-Grains Research Project**
- USFWS Montana Fish and Wildlife Conservation Offices
- USFWS Aquatic Animal Drug Approval Partnership Program

Database of Nutrient Digestibility's of Traditional and Novel Feed Ingredients for Trout and Hybrid Striped Bass

F.T. Barrows[1], T.G. Gaylord[2], W. Sealey[2], S.D. Rawles[3]

This is a collaborative project among;

USDA-Agricultural Research Service
National Program 106 - Aquaculture
[1]Trout-Grains Project, Aberdeen and Hagerman ID and Bozeman, MT
[3]H. K. Dupree Stuttgart National Aquaculture Research Center, Stuttgart, AR

USDOI- Fish and Wildlife Service
[2]Fish Technology Center, Bozeman Montana

Description

The determination of nutrient digestibility's in specific ingredients and diets for fish has been an area of active research for decades. The Apparent Digestibility Coefficients (ADC), the percentage of nutrients in an ingredient that are available to the fish, is information needed by researchers, producers, and feed mills to accurately formulate feeds and thus meet the needs of the animal without excess. ADC's are also necessary for determining the nutritional and economic value of alternative ingredients. Data developed from many different laboratories have been compiled in publications such as the NRC (1993), and often show extreme variability. This is not unexpected since there are many factors that can affect the ADC of an ingredient, including basal diet formulation, method of feed manufacturing (cooking versus cold formation), fecal collection method, etc. Different laboratories often use a mixture of methods specific to that laboratory.

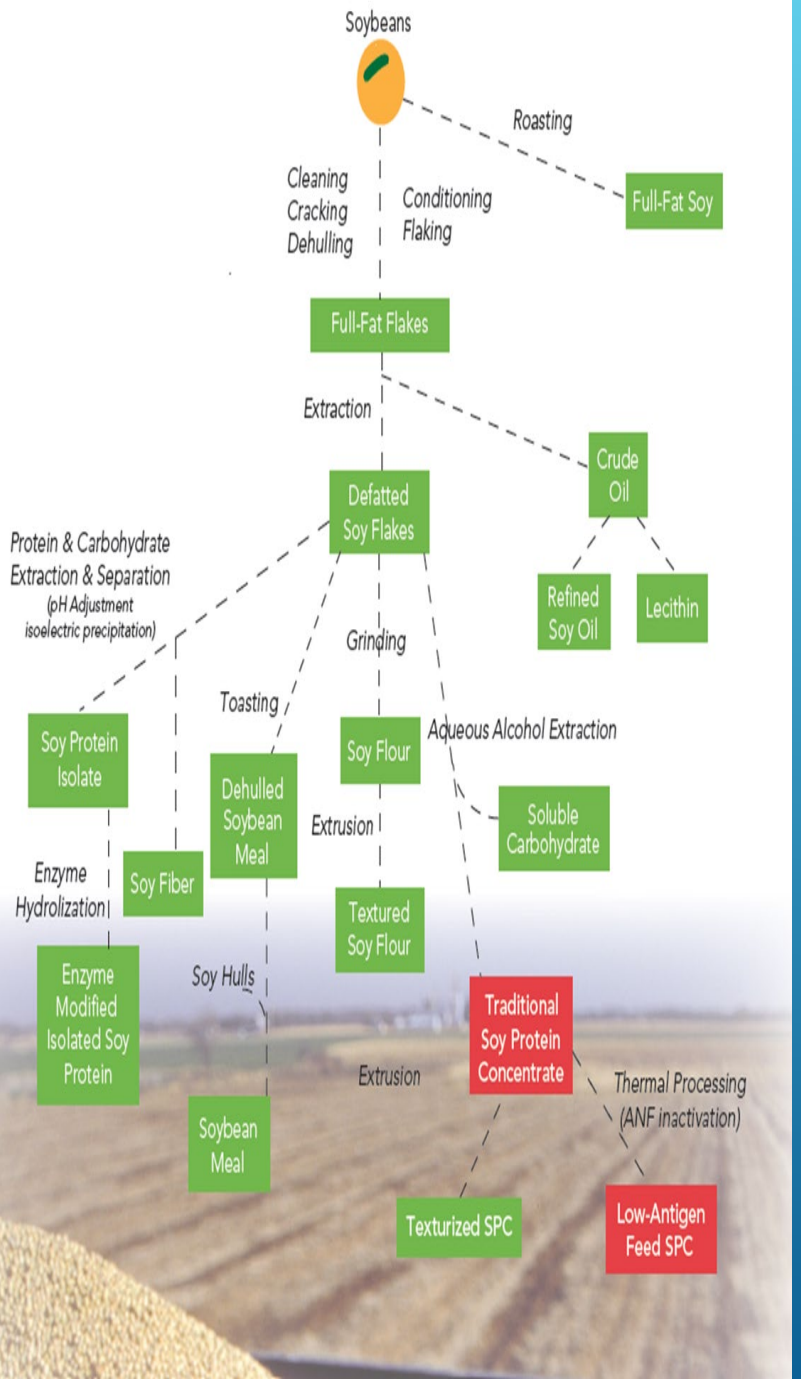
Rainbow Trout over 150 entries

Fish Feed and Nutrition Laboratory (Lab scale Feed Mill), Bozeman, Montana

H.K. Dupree Stuttgart National Aquaculture Research Center, Stuttgart, Arkansas

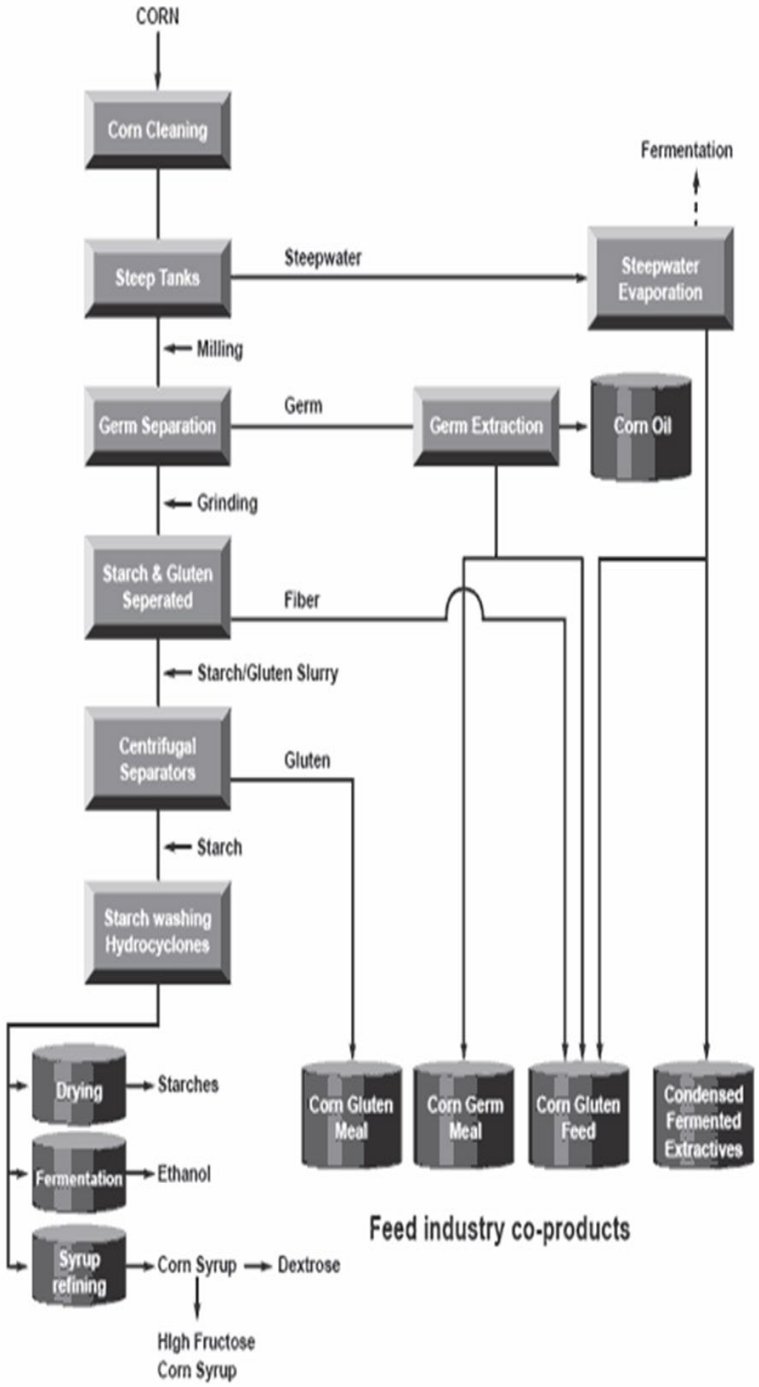
INGREDIENT SHIFTS

- In early 1990s, aquafeeds used ~12% of annual fish meal and fish oil production; most fish meal was used in poultry and swine feeds
- Today, aquafeeds use >65% of average annual fish meal production and 90% of fish oil even though inclusion levels are at historic lows
- And as fishmeal levels have declined incorporation of plant and high-quality animal protein material has risen in feeds.



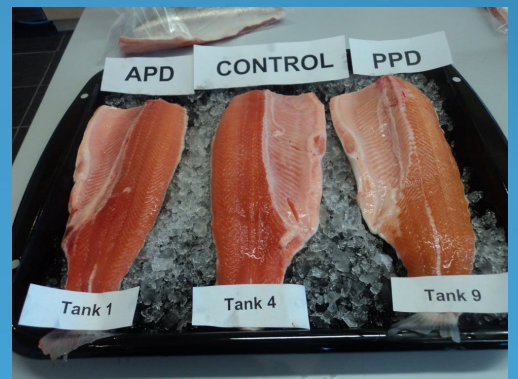
PLANT Protein By-products

- Secondary products from oil or starch production
- Consider carbohydrate content
- Amino acids limitations—lysine and methionine
- Anti-nutritional factors
- Very low phospholipid content
- Worldwide protein production
  - Soybean meal
  - Soy Protein Concentrate



Grains And By-products

- Grains are used as carbohydrate sources
- Starches are 60-70% digestible by warm-water, but less so by cold-water fish
- Extrusion may improve digestibility 10-15% and help bind feed
- Corn and wheat commonly used
- Pigments can be problematic
- Processed grains often better
  - Corn gluten meal high in protein (60%) and has more methionine than SBM
  - Wheat gluten



EXPANDING USE OF DISTILLERS PRODUCTS IN AQUACULTURE DIETS

- Grain Distillers Dried Yeast
- Distillers Dried Grains with solubles (DDGS)
- HP DDGS

GDDY IN AQUAFEEDS

- *Saccharomyces cerevisiae* has been commonly used in aquaculture
- Nutrient content of GDDY (Hauptman et al. 2014)

Item, % Dry wt basis	FM	EY
DM	93.45	94.45
Fat	11.73	7.31
Crude Protein	63.42	46.59

- Contains non-protein nitrogen in the form of nucleic acids, about 10–25% of crude protein
- Inactive/non-functional yeast

  - Agboola, J.O., Øverland, M., Skrede, A. and Hansen, J.Ø. (2021), Yeast as major protein-rich ingredient in aquafeeds: a review of the implications for aquaculture production. Rev. Aquacult., 13: 949-970. https://doi.org/10.1111/raq.12507

GDDY IN AQUAFEEDS

Amino Acid Comparison

Item, %	FM	EY
Sum AA	66.3	44.0
His	1.4	1.0
Ile	2.8	2.1
Leu	5.1	5.2
Lys	4.4	2.3
Met	2.1	1.0
Phe	2.9	2.4
Thr	3.2	1.9
Try	2.3	0.5
Val	3.8	2.5

Hauptman, B.S., F.T. Barrows, S.S. Block, T.G. Gaylord, J.A. Paterson, S.D. Rawles and **W.M. Sealey** (2014). Evaluation of Grain Distillers Dried Yeast as a Fish Meal Substitute in Practical-Type Diets of Juvenile Rainbow Trout, *Oncorhynchus mykiss.* Aquaculture. 432: 7-14.

GDDY IN AQUAFEEDS

AAC	FM	EY
Sum AA	97.0	81.0
His	97.0	79.0
Ile	96.0	79.0
Leu	97.0	84.0
Lys	98.0	76.0
Met	97.0	88.0
Phe	96.0	89.0
Thr	97.0	71.0
Try	96.0	85.0
Val	94.0	79.0

Hauptman, B.S., F.T. Barrows, S.S. Block, T.G. Gaylord, J.A. Paterson, S.D. Rawles and **W.M. Sealey** (2014). Evaluation of Grain Distillers Dried Yeast as a Fish Meal Substitute in Practical-Type Diets of Juvenile Rainbow Trout, *Oncorhynchus mykiss.* Aquaculture. 432: 7-14.

Distillers Industry Co-Products

Grain Distiller's Dried Yeast

Rainbow trout

Hauptman et al. 2014a,b
Sealey et al. 2014a
Betiku et al. 2018

Atlantic salmon

Burr et al. 2020

1. Hauptman, B.S., F.T. Barrows, S.S. Block, T.G. Gaylord, J.A. Paterson, S.D. Rawles and **W.M. Sealey** (2014). Evaluation of Grain Distillers Dried Yeast as a Fish Meal Substitute in Practical-Type Diets of Juvenile Rainbow Trout, *Oncorhynchus mykiss.* Aquaculture. 432: 7-14.
2. Hauptman, B.S., F.T. Barrows, S.S. Block, T.G. Gaylord, J.A. Paterson, and **W.M. Sealey** (2014). Potential for a Mycotoxin Deactivator to Improve Growth and Performance of Rainbow Trout fed High Levels of an Ethanol Industry Co-Product, Grain Distiller's Dried Yeast. North American Journal of Aquaculture. 76: 297-304.
3. **Sealey, W.M**., T.J. O'Neill, J.T. Peach, T.G. Gaylord, F.T. Barrows and S.S. Block (2015) Refining Inclusion Levels Of Grain Distillers Dried Yeast In Commercial-Type And Plant-Based Diets For Juvenile Rainbow Trout (*Oncorhynchus mykiss)*. Journal of the World Aquaculture Society. 46:434-444.
4. Betiku, O. C., Yeoman, C. J., Gaylord, T. G., Duff, G. C., Hamerly, T., Bothner, B., Block, S.S. and **Sealey, W. M**. (2018). Differences in Amino Acid Catabolism by Gut Microbes with/without Prebiotics Inclusion in GDDY-based Diet Affect Feed Utilization in Rainbow Trout. Aquaculture 490:108-119.
5. Burr, G.; Peterson, B. Pietrak, M.; **Sealey, W.M.**; Bowzer, J., Block, S. (2020). Effect of PROPLX DY and PROPLX T on growth performance of Atlantic salmon smolts. Aquaculture Research 51:4689-4697.

EXPANDING USE OF DISTILLERS PRODUCTS IN AQUACULTURE DIETS

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- Distillers Dried Grains with solubles (DDGS)
- HP DDGS

DDGS IN AQUAFEEDS

- Distillers Dried Grains with solubles (DDGS) have been investigated in aqua feeds since the late 1940s.
- Traditional DDGS (approximately 306 g kg-1 CP and 100 g kg-1 lipid)
- The carbohydrate (CHO) concentration of the ingredient could be a potential factor limiting inclusion when formulating diets

- Gyan Watson Ray, Xuehe Li, Shuqing He, Huaxing Lin, Qihui Yang, Beiping Tan, Xiaohui Dong, Shuyan Chi, Hongyu Liu, Shuang Zhang, A Review on the Use of Distillers Dried Grains with Solubles (DDGS) in Aquaculture Feeds, Annals of Animal Science, 10.2478/aoas-2021-0041, **22**, 1, (21-42), (2022).

Fuel Industry Co-Products

Distiller's Dried Grains with Solubles

Sealey et al. 2015

1. **Sealey, W.M**., C.G. Hooley, K.A. Rosenstrater, T.G. Gaylord, and F.T. Barrows (2015) The Effect of a Mycotoxin Deactivation Product on Growth of Juvenile Rainbow Trout *(Oncorhynchus mykiss*) Fed Dried Distiller's Grains. North American Journal of Aquaculture. 77:429-436.

Sealey, Tan, and Welker 2022

2. Current study: **Evaluating the ability of exogenous enzymes to improve digestibility and growth performance of Tilapia fed traditional Dried Distiller's Grains**

HP Distiller's Dried Grains with Solubles

Gaylord, Tilton and Sealey 2022

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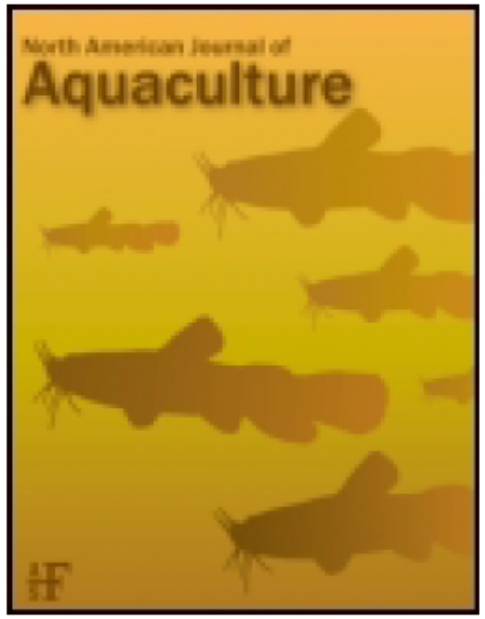

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The Effect of a Mycotoxin Deactivation Product on Growth of Juvenile Rainbow Trout Fed Distillers Dried Grains

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[b] Distillers Grains Technology Council, Department of Agricultural and Biosystems Engineering, Iowa State University, 3327 Elings Hall, Ames, Iowa 50011, USA

[c] U.S. Department of Agriculture, Agricultural Research Service, Trout Grains Project, Bozeman Fish Technology Center,, 4050 Bridger Canyon Road, Bozeman, Montana 59715, USA

Published online: 29 Jul 2015.

Sealey et al .2015

DDGS Digestibility data

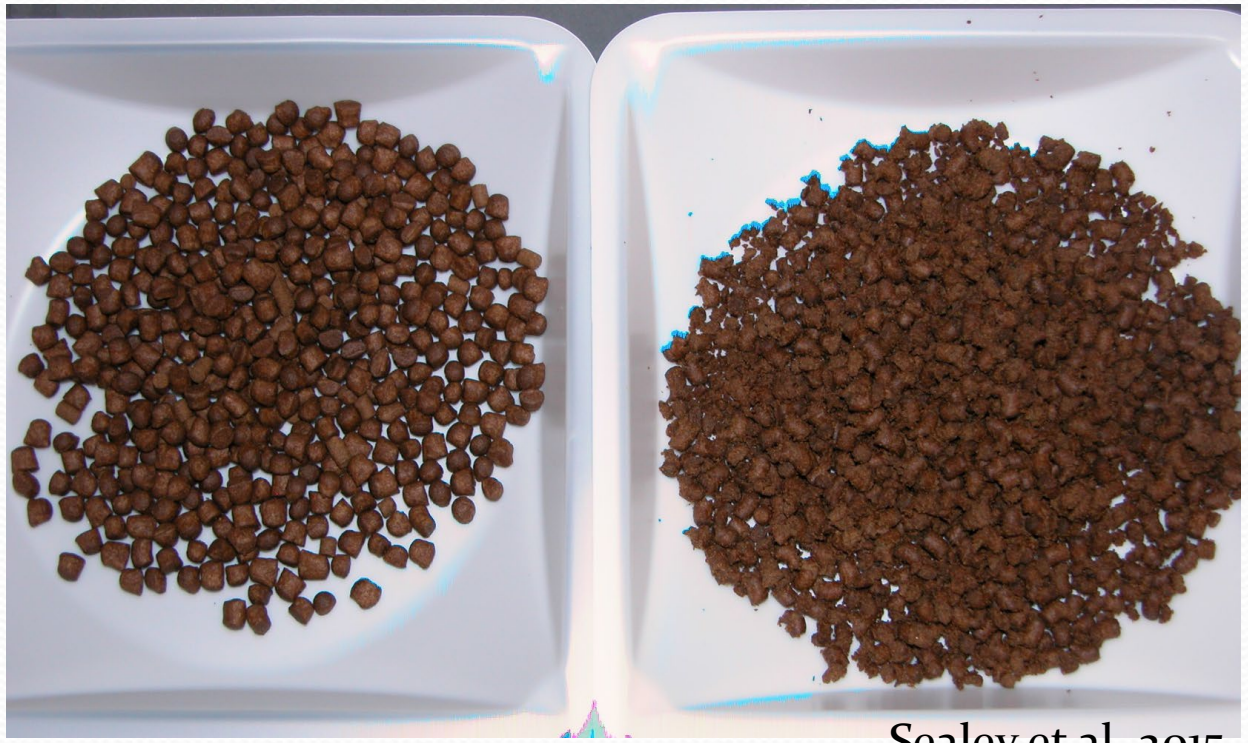
Amino acids	High Protein	Valero	Wentworth
Ala	84	92	82
Arg	89	99	90
Asp	70	91	69
Glu	83	95	83
Gly	56	81	57
His	82	90	79
Ile	78	89	76
Leu	90	97	86
Lys	69	79	68
Met	75	99	85
Phe	67	82	68
Pro	83	92	80
Ser	73	88	77
Thr	67	78	72
Tyr	88	95	88
Val	77	86	76

Sealey et al .2015

Ingredient (%DM)	FM	HPDDG
HPDDG	0.0	23.8
FM Average	24.9	13.5
Wheat flour	17.7	3.0
Corn Protein	5.0	5.0
Poultry blood meal	3.1	3.2
Soybean meal	14.9	15.1
Chicken concentrate	14.2	14.4
Menhaden fish oil	13.7	13.5
Lecithin	0.9	0.9
Stay-C 35	0.2	0.2
Vitamin premix ARS	0.9	0.9
TM ARS 640	0.1	0.1
NaCl	0.3	0.3
Magnesium Oxide	0.1	0.1
Potassium chloride	0.5	0.5
Choline Cl 50%	0.9	0.9
Taurine	0.5	0.5
Ytrium	0.1	0.1
Dical Phosphate	0.0	1.2
DL-Methionine	0.4	0.5
Lysine HCl	1.5	1.9
Threonine	0.1	0.2

Pellet Quality

- 0% 24% inclusion



Sealey et al .2015

Protein: P < 0.001

Supplement: P = 0.7515

PxS: P = 0.5570

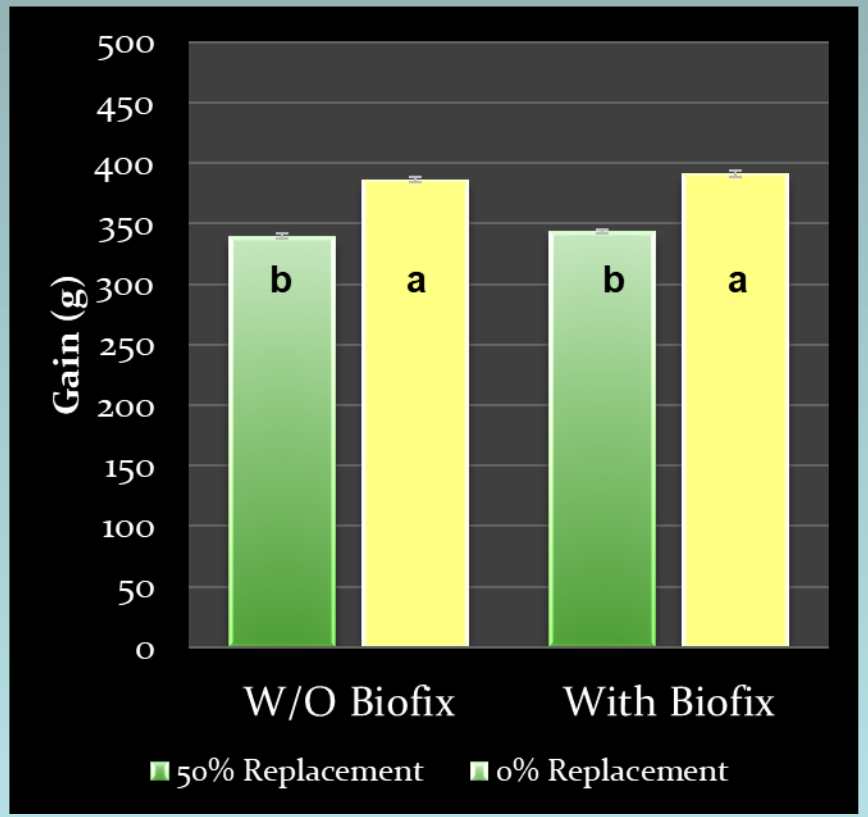
Protein: P = 0.9130

Supplement: P = 0.0561

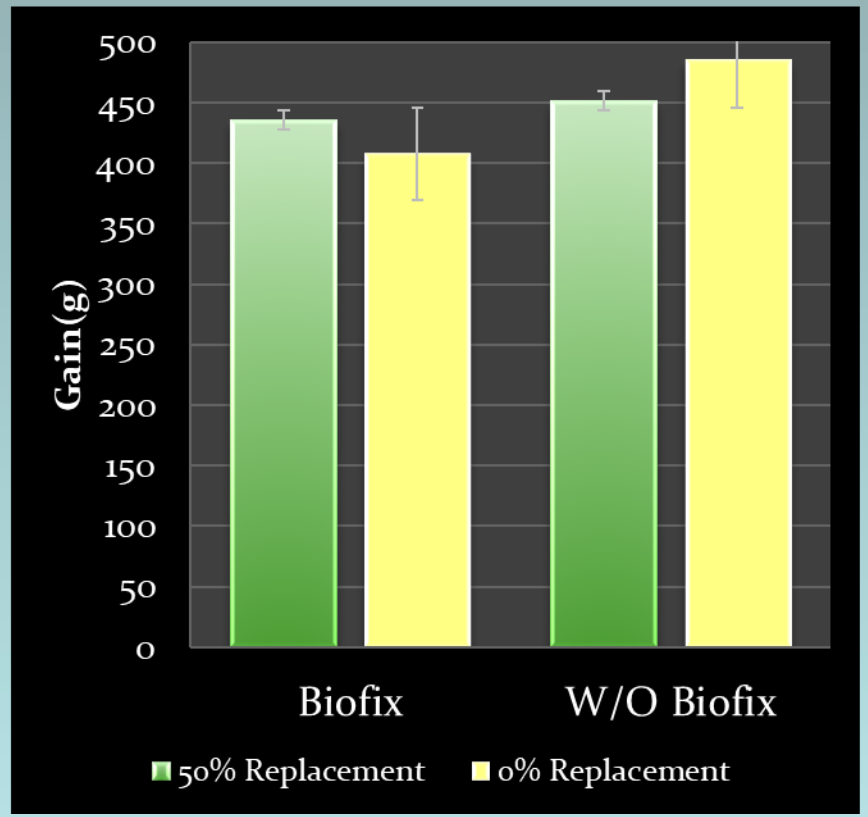
PxS: P = 0.1882

Growth (% Increase)

Feeding Trial 1



Feeding Trial 2



Sealey et al. 2015

HP-DDGS

- **Confusion over products**
  - "Published literature often misconstrues traditional and HP-DDGS"
  - It is understood that HP-DDGS (a total dietary fiber reduced ingredient) is more desirable when replacing fish-derived protein feedstuffs due to its higher protein content and more readily digested nutrients
- **Variability in protein levels in HP products**
- **Lack of published data on novel products**

FUEL INDUSTRY CO-PRODUCTS

Distiller's Dried Grains with Solubles

Sealey et al. 2015

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HP Distiller's Dried Grains with Solubles

Gaylord, Tilton and Sealey 2022

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Examination of The Andersons Inc. products ability to replace fishmeal in Juvenile Rainbow Trout (Oncorhynchus mykiss)

T. Gibson Gaylord, Scott Tilton, and Wendy M. Sealey

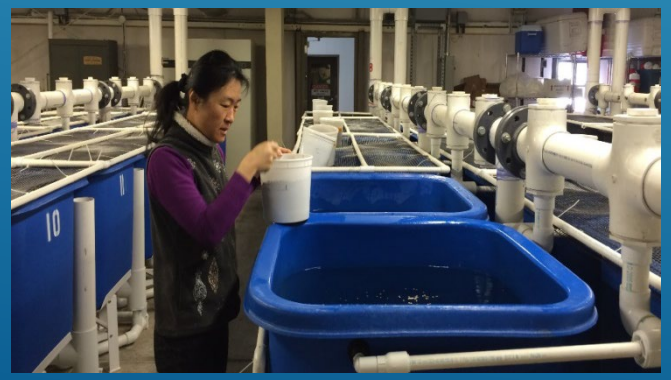
DIGESTIBILITY REFERENCE DIET

Ingredient	% (dry wt)
Wheat flour	28.3
Squid meal	25.0
Soy protein concentrate [1]	17.1
Corn gluten meal	8.3
Soybean meal	4.3
Vitamin premix ARS	1.0
Stay-C 35	0.2
Trace mineral premix	0.1
Chromic oxide	1.0
Choline chloride	0.6
Taurine	0.5
Fish oil	13.4
Proximate Composition	
Crude Protein (CP)	40.5
Crude Lipid (CL)	15.5
Phosphorus (P)	0.8
Yttrium oxide	0.1

- Reference diet meeting known nutritional requirements of fish will be blended with test ingredient
  - 70:30 ratio (dry-wt. basis)
  - Reference, MFM, ADY 40Y, ADY 50Y
- Nutrient and energy availability determined
  - Yttrium oxide to determine feed intake

FEEDING REGIMEN

- 15 tanks randomly assigned to one of 6 diets
  - 3 tanks/trt
- Fed 2x day for 15 days
- Fecal samples-collected 16-18hrs post feeding
  - Fecal matter freeze-dried, stored at -20°C until processing



DIGESTIBILITY TRIAL DATA

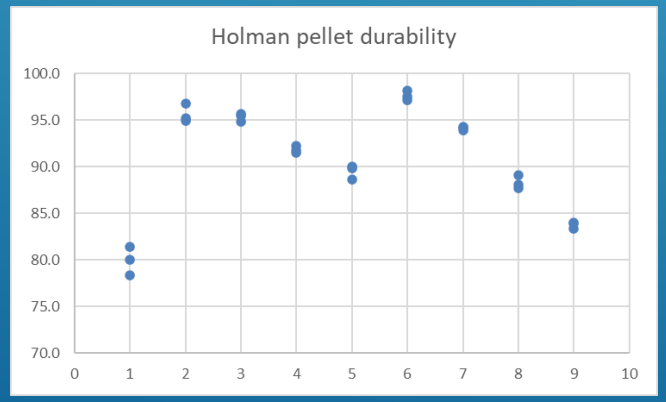
Proximate Analaysis						
		DM	Fat %	Protein %	Energy (cal/g)	P
Menhaden Fish Meal (Special Select)		93.11	9.55	70.78	4666.38	3.7853
ANDVantage 50Y		93.64	10.13	54.78	5608.29	0.5981
ANDVantage 40Y		93.16	9.96	44.22	5406.99	0.5606
Apparent Digestibility Coefficients						
		DM	Fat %	Protein %	Energy (cal/g)	P
Menhaden Fish Meal (Special Select)		83.3	104.9	83.4	104.2	35.5
ANDVantage 50Y		59.9	98.3	83.0	72.5	40.3
ANDVantage 40Y		59.8	98.1	81.7	70.7	86.3

DIGESTIBILITY TRIAL DATA

	Menhaden Fish Meal	ANDVantage 50Y	ANDVantage 40Y
Sum AA	88.4	84.7	84.5
ALA	87.8	86.8	87.5
ARG	90.4	89.7	87.4
ASP	85.5	77.5	76.8
CYS	84.1	74.9	72.8
GLU	91.5	88.1	89.3
GLY	77.3	76.0	72.3
HIS	90.1	85.4	83.0
ILE	92.1	82.9	81.4
LEU	93.4	88.4	90.3
LYS	91.5	76.4	69.3
MET	90.7	89.7	90.0
PHE	90.2	87.0	87.5
PRO	83.1	86.6	87.5
SER	87.1	82.9	83.9
THR	89.5	77.2	74.3
TRP	92.6	86.5	79.2
TYR	94.3	91.2	92.3
VAL	90.4	84.3	82.4

TROUT DIETS WITH HPDDGS

DP 42%, CL 20%, AP 0.6%

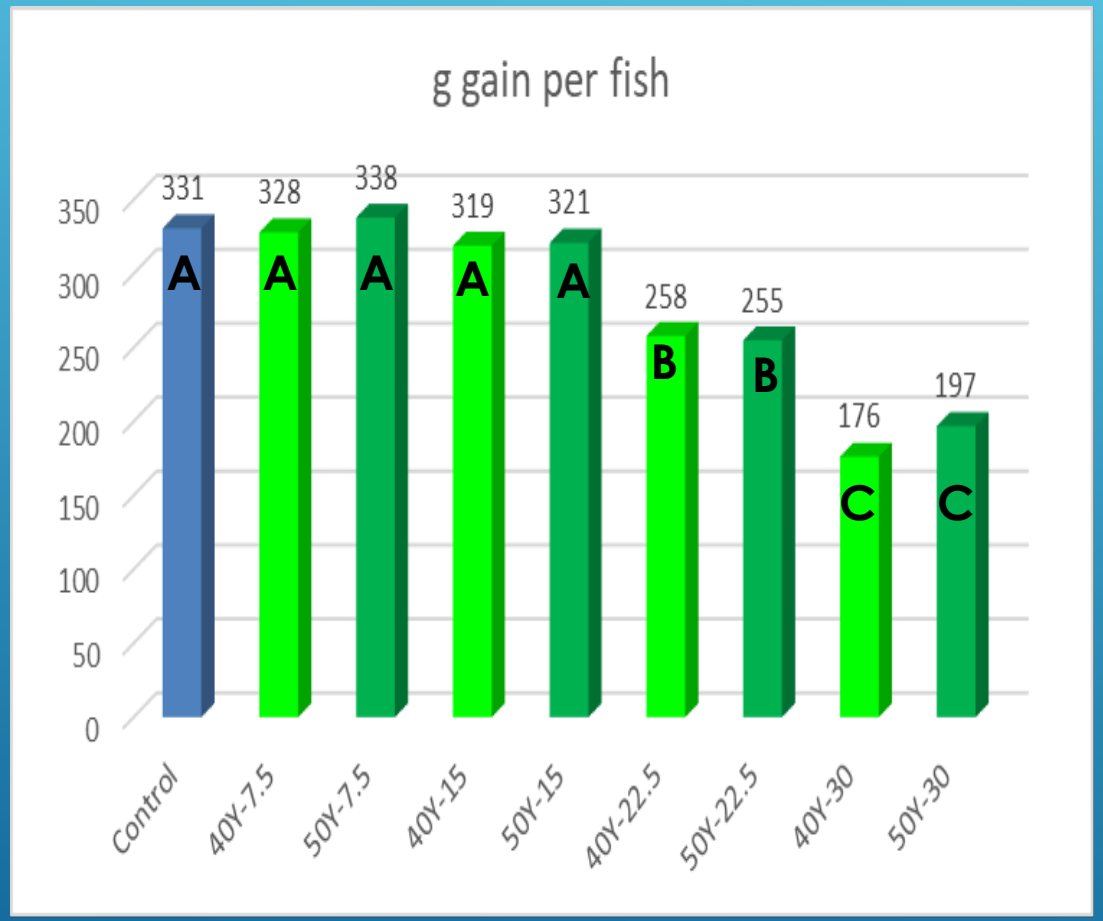


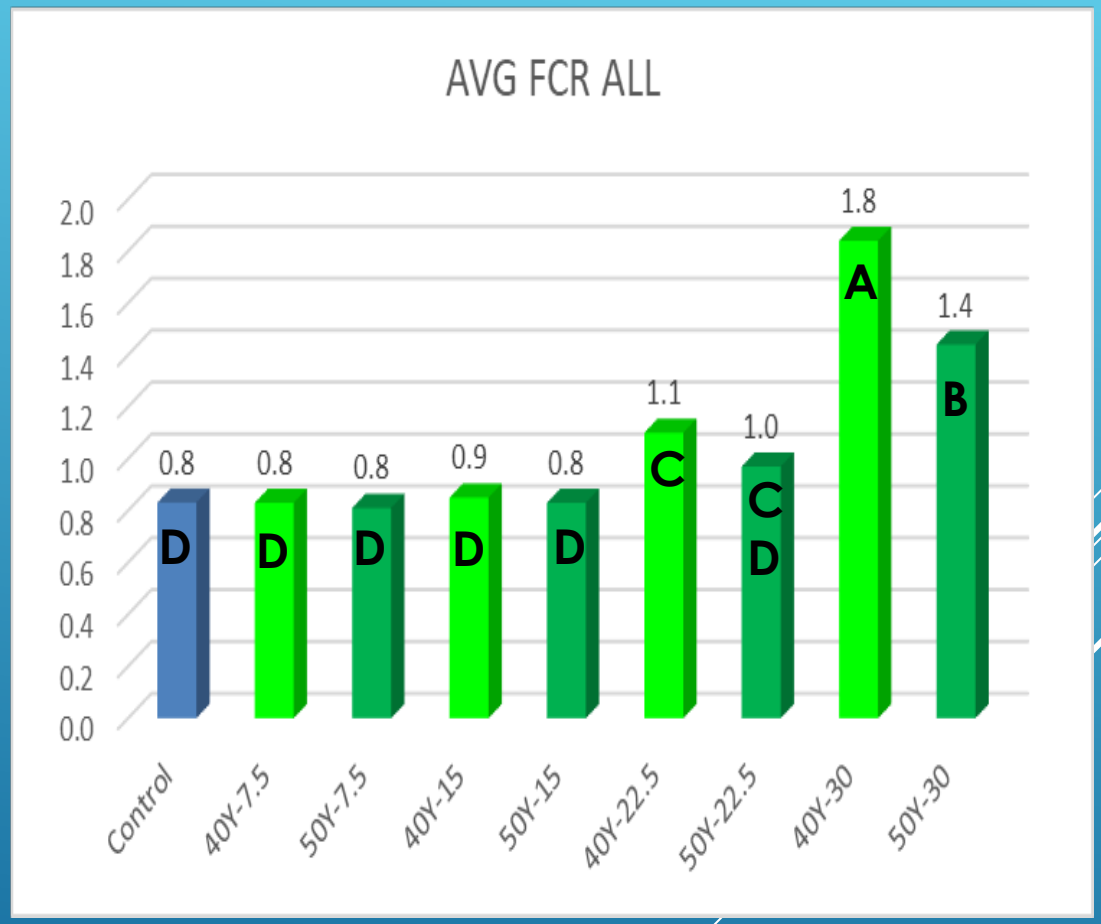
Ingredients	Control	40Y-30	40Y-22.5	40Y-15	40Y-7.5		50Y-30	50Y-22.5	50Y-15	50Y-7.5
Menhaden Fish Meal	**15.3**	**6.1**	**8.4**	**10.7**	**12.9**		**3.7**	**6.6**	**9.5**	**12.3**
Chicken 42 - ADF	**11.7**	**4.7**	**6.4**	**8.2**	**10.0**		**2.8**	**5.1**	**7.3**	**9.5**
ANDVantage 40Y	**0.0**	**30.0**	**22.5**	**15.0**	**7.5**		**0.0**	**0.0**	**0.0**	**0.0**
ANDVantage 50Y	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**		**30.0**	**22.5**	**15.0**	**7.5**
Menhaden fish oil	**12.3**	**11.9**	**12.0**	**12.1**	**12.2**		**12.3**	**12.3**	**12.3**	**12.3**
Wheat gluten meal	**0.0**	**1.9**	**1.5**	**1.0**	**0.5**		**1.6**	**1.2**	**0.8**	**0.4**
Mayflower pastry flour	**20.8**	**4.3**	**8.4**	**12.6**	**16.8**		**7.3**	**10.7**	**14.1**	**17.5**
Monocalcium Phosphate	**2.15**	**2.5**	**2.4**	**2.3**	**2.2**		**3.6**	**3.2**	**2.9**	**2.5**
DL-Methionine	**0.54**	**0.55**	**0.55**	**0.55**	**0.54**		**0.51**	**0.52**	**0.52**	**0.53**
Lysine HCl	**1.68**	**2.42**	**2.23**	**2.05**	**1.86**		**2.53**	**2.32**	**2.1**	**1.89**
Threonine	**0.46**	**0.62**	**0.58**	**0.54**	**0.5**		**0.64**	**0.6**	**0.55**	**0.51**
Corn Protein Concentrate	*5*	*5*	*5*	*5*	*5*		*5*	*5*	*5*	*5*
Blood meal- AP301	*5*	*5*	*5*	*5*	*5*		*5*	*5*	*5*	*5*
Feather meal	*5*	*5*	*5*	*5*	*5*		*5*	*5*	*5*	*5*
Commodity SBM	*15*	*15*	*15*	*15*	*15*		*15*	*15*	*15*	*15*
Lecithin	*1*	*1*	*1*	*1*	*1*		*1*	*1*	*1*	*1*
Stay-C 35	*0.2*	*0.2*	*0.2*	*0.2*	*0.2*		*0.2*	*0.2*	*0.2*	*0.2*
Vitamin premix ARS 702	*1*	*1*	*1*	*1*	*1*		*1*	*1*	*1*	*1*
NaCl	*0.28*	*0.28*	*0.28*	*0.28*	*0.28*		*0.28*	*0.28*	*0.28*	*0.28*
Magnesium Oxide	*0.06*	*0.06*	*0.06*	*0.06*	*0.06*		*0.06*	*0.06*	*0.06*	*0.06*
Potassium chloride	*0.56*	*0.56*	*0.56*	*0.56*	*0.56*		*0.56*	*0.56*	*0.56*	*0.56*
Choline Cl 50%	*1*	*1*	*1*	*1*	*1*		*1*	*1*	*1*	*1*
Taurine	*0.5*	*0.5*	*0.5*	*0.5*	*0.5*		*0.5*	*0.5*	*0.5*	*0.5*
TM ARS 1440	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		*0.1*	*0.1*	*0.1*	*0.1*
Astaxanthin	*0.08*	*0.08*	*0.08*	*0.08*	*0.08*		*0.08*	*0.08*	*0.08*	*0.08*
Ca Proprionate	*0.15*	*0.15*	*0.15*	*0.15*	*0.15*		*0.15*	*0.15*	*0.15*	*0.15*
Yttrium oxide	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*		*0.1*	*0.1*	*0.1*	*0.1*
Sum with oil:	100	100	100	100	100		100	100	100	100

FEEDING TRIAL METHODS

- 20 rainbow trout (avg. 38g/fish) per tank (325 L/tank)
- 27 tanks randomly assigned to one of nine diets
  - 3 tanks/trt
- Fed 2x day for 12 wks
- Temp. maintained at ~14°C
- Recirculating spring water system
- 13 h light :11 h dark

FEEDING TRIAL RESULTS





P<0.0001

HP-DDGS

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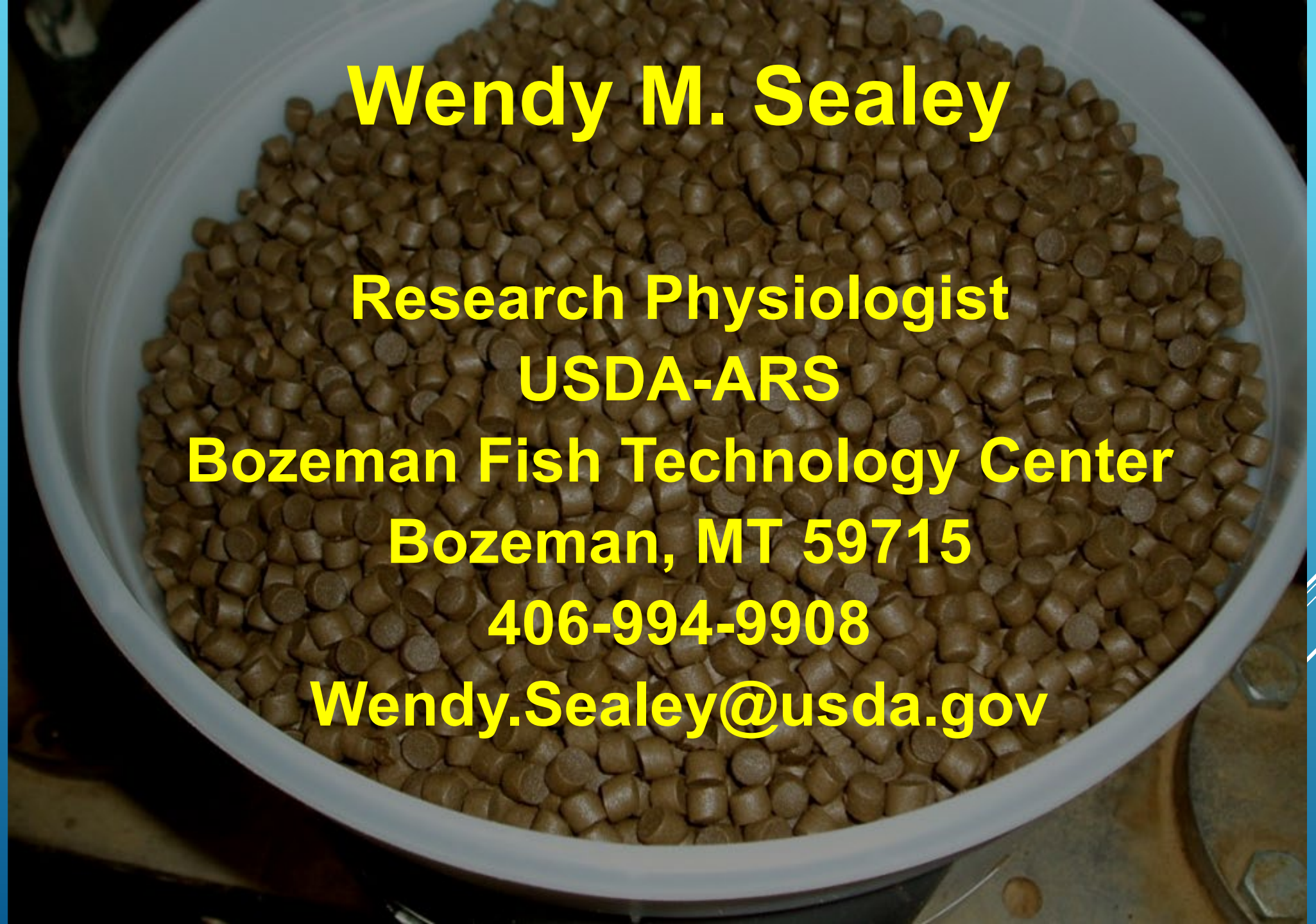
EXPANDING USE OF DISTILLERS PRODUCTS IN AQUACULTURE DIETS

1) Continue education initiatives to differentiate product types
2) Protein Digestibility/AA Availability data is essential
3) Support research in a variety of aquatic species (catfish, shrimp, salmonids) and publish the results!

May 12, 2022

Thank you for your attention!
Questions?



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