ENZYMES IN FEED APPLICATIONS:

IMPROVING DIGESTIBILITY
REDUCING FEED COSTS
REDUCING MANURE AND POLLUTIVE EFFECTS

JOEL F. MANGALINDAN DVM
CLINICAL NUTRITION PRACTITIONER
ENZYME APPLICATIONS IN ANIMAL FEED

MOST SIGNIFICANT FEED EFFICIENCY IMPROVEMENT IN OVER A DECADE

UNDERSTANDING THE FACTS THAT LED TO ITS DEVELOPMENT AND THE SCIENCE BEHIND THE TECHNOLOGY

DEBUNKING MYTHS
PHILIPPINES IMPORTS OVER 50%-65% OF ITS FEED REQUIREMENT (FAO, USDA data)

- AUTOMATICALLY INCREASES FEED COSTS BY >10% OVER PRIMARY PRODUCER COUNTRIES

> TRANSLATING TO AT LEAST 8% HIGHER PRODUCTION COSTS

Underscores the need for a more efficient feed utilization and conversion and use of locally available and cheaper by-products
HOW MUCH MONEY DO THE PIG AND POULTRY FARMS THROW AWAY WITH THE MANURE EVERYDAY?
FEED APPLICATION OF APPROPRIATE ENZYME TECHNOLOGY

PURPOSELY DEVELOPED BY THE SCIENCE COMMUNITY

TO LEVEL THE PLAYING FIELD IN PRODUCTION COSTS BY MITIGATING THE SIGNIFICANT FEED COSTS DIFFERENCE

TO ADDRESS THE DIGESTIBILITY DEFICIENCIES OF CORN-SOY IN MONOGASTRICS

TO MARKEDLY REDUCE THE MANURE AND EFFLUENTS PRODUCTION OF ANIMAL FARMS AND THEIR PERVASIVE DESTRUCTIVE IMPACT ON THE ENVIRONMENT
IN A TYPICAL CORN-SOY RATION

OVER 25% OF THE CARBOHYDRATES
OVER 60% OF THE PROTEINS
OVER 1/3 OF THE TOTAL FEED

ARE UNDIGESTED/UNUSED AND EXCRETED
AS MANURE/URINE
TYPICAL PROTEIN INTAKE, UTILIZATION AND EXCRETION IN PIGS: PROTEIN BIOLOGIC VALUE OF STANDARD CORN-SOY RATION

<table>
<thead>
<tr>
<th>Feed</th>
<th>Retention</th>
<th>Feces</th>
<th>Urine</th>
</tr>
</thead>
<tbody>
<tr>
<td>55 gm N/100%</td>
<td>17 gm N/30%</td>
<td>11 gm N/20%</td>
<td>27 gm N/50%</td>
</tr>
</tbody>
</table>

*Adapted from: Aarnink, et.al. 1997; Nitrogen Chain tests on growing-finishing pigs
EFFECT OF NUTRIENT CONTENT IN DIETS ON NUTRIENT BALANCE, TYPICAL NITROGEN AND P CONSUMPTION, DEPOSITION AND EXCRETION PROFILE IN PIGS
kg/sow/yr

<table>
<thead>
<tr>
<th></th>
<th>Phosphorous</th>
<th>Protein (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High</td>
<td>Basal</td>
</tr>
<tr>
<td>Per Sow Integrated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(includes 22 pigs/sow/yr to slaughter)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumed (kg)</td>
<td>39.1</td>
<td>27.9</td>
</tr>
<tr>
<td>Deposited (kg)</td>
<td>11.2</td>
<td>11.2</td>
</tr>
<tr>
<td>Excreted (kg)</td>
<td>27.9</td>
<td>16.7</td>
</tr>
<tr>
<td>% Excreted</td>
<td>71</td>
<td>60</td>
</tr>
</tbody>
</table>

(manure & urine)

# NITROGEN (PROTEIN) EXCRETION POULTRY

<table>
<thead>
<tr>
<th></th>
<th>DIET CP %</th>
<th>NITROGEN OUTPUT/DAY in gms</th>
<th>N EXCRETION % OF TOTAL N INTAKE</th>
</tr>
</thead>
<tbody>
<tr>
<td>BROILERS (3-6 WKS)</td>
<td>21</td>
<td>2.70</td>
<td>62.49</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>1.98</td>
<td>54.40</td>
</tr>
<tr>
<td>LAYERS</td>
<td>18</td>
<td>2.30</td>
<td>66.90</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>1.39</td>
<td>60.14</td>
</tr>
</tbody>
</table>

*adapted fr: CANADA-BC GREEN PLAN FOR AGRICULTURE 2012; AGRIaccess data
### TYPICAL MANURE OUTPUT AND VALUES PHIL.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>manure* output</th>
<th>VALUE**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broiler/hd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35 day harvest</td>
<td>0.78-1.1 kg</td>
<td>25.16 pesos</td>
</tr>
<tr>
<td>layer, per day</td>
<td>33-38 gm</td>
<td>0.7 pesos</td>
</tr>
<tr>
<td>finisher pig/day</td>
<td>0.9-1.05 kg</td>
<td>16.1 pesos</td>
</tr>
</tbody>
</table>

*typical, dry basis, 2004-2012 Agriaccess data, Phil. farms
**based on typical current 2014 cost/kg of feed
55% - 70% of protein intake is undigested/unused and excreted with the manure/urine.

26% - 35% of daily feed intake is undigested and thrown out with the manure.
A 1,000 SOW UNIT TYPICALLY PRODUCES 4-5 TONS OF MANURE/DAY, THROWING AWAY EQUIVALENT OF 72,000pesos/DAY

A 50,000 LAYER FARM PRODUCES 1,500KG OF MANURE/DAY, THROWING AWAY THE EQUIVALENT OF 32,000pesos/DAY

A 100,000 BROILER FARM PRODUCES 90,000KG OF MANURE/GROW THROWING AWAY THE EQUIVALENT OF OVER 2Mpesos/GROW
MANURE REPRESENTS ALL THAT IS INDIGESTIBLE, INABSORBABLE AND NON-BIOAVAILABLE IN THE FEED

MANURE COMPOSITION ANALYSIS DATA*
REFLECT

35-48% Total Fiber (NDF)
18-26% Crude Protein (fecal and urinary origin)

*Agriaccess Data Phil. Farms 2004-2012
THE ISSUE THEREFORE IS REALLY A MATTER OF DIGESTIBILITY OF FEED**
INDICATIVE CAUSES #1

INDIGESTIBLE FIBERS IN PLANT INGREDIENTS

FIBERS are carbohydrate polymers that are β (beta) linked, and thus are indigestible to monogastric pig and poultry, as they do not produce β enzymes.

STARCH are carb polymers that are α (alpha) linked, and thus are digestible to monogastrics, as they produce α enzymes.

Fibers are now defined as non-starch polysaccharides (NSP) to differentiate from starch.
**alpha linked d-1,4 glucose**  
STARCH

**beta linked d-1,4 mannose**  
FIBER
### FIBER/NON-STARCH POLYSACCHARIDE (NSP) PROFILES OF SOME COMMON INGREDIENTS, BY PRODUCTS AND NON-TRADITIONAL INGREDIENTS

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>NDF (%)</th>
<th>ADF (%)</th>
<th>HC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain</td>
<td>9.6</td>
<td>2.8</td>
<td>6.8</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>13.3</td>
<td>9.4</td>
<td>3.9</td>
</tr>
<tr>
<td>Wheat, hard red</td>
<td>14.0</td>
<td>4.5</td>
<td>9.5</td>
</tr>
<tr>
<td>Cassava meal, chips</td>
<td>29.5</td>
<td>9.1</td>
<td>20.4</td>
</tr>
<tr>
<td>Rice bran</td>
<td>23.7</td>
<td>13.9</td>
<td>9.8</td>
</tr>
<tr>
<td>Brewer’s rice (binlid)</td>
<td>12.2</td>
<td>3.1</td>
<td>9.1</td>
</tr>
<tr>
<td>Sorghum pollard</td>
<td>18.0</td>
<td>8.3</td>
<td>9.7</td>
</tr>
<tr>
<td>Palm kernel meal, exp.</td>
<td>42.1</td>
<td>13.0</td>
<td>29.1</td>
</tr>
<tr>
<td>DDGS</td>
<td>43.0</td>
<td>12.8</td>
<td>30.2</td>
</tr>
<tr>
<td>Copra meal, solv</td>
<td>51.3</td>
<td>25.5</td>
<td>25.8</td>
</tr>
</tbody>
</table>

*Adapted fr: NRC 2012; Agriaccess data 2004-2013

NDF = Neutral Detergent Fiber  
ADF = Acid Detergent Fiber (cellulose+lignin)  
HC = hemicellulose  

**CRUDE FIBER IN STANDARD FEED ANALYSIS COMPRISSES OF LIGNIN AND CELLULOSE**
### MAJOR NSP SUBSTRATE (FIBER) PROFILES OF COMMON FEEDSTUFFS/RATIONS

<table>
<thead>
<tr>
<th>CORN-SOY</th>
<th>GRAINS</th>
<th>OIL SEEDS</th>
<th>OIL NUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>wheat</td>
<td>wheat</td>
<td>soybean meal</td>
<td>copra meal</td>
</tr>
<tr>
<td>rice</td>
<td>rice</td>
<td>canola meal</td>
<td>palm kernel meal</td>
</tr>
<tr>
<td>corn</td>
<td>corn</td>
<td></td>
<td>guar meal</td>
</tr>
<tr>
<td>brans</td>
<td>brans</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>cellulose</th>
<th>cellulose</th>
<th>cellulose</th>
<th>cellulose</th>
</tr>
</thead>
<tbody>
<tr>
<td>xylan</td>
<td>xylan</td>
<td>betamannan</td>
<td>betagalactomannan</td>
</tr>
<tr>
<td>betaglucan</td>
<td>betaglucan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*ADAPTED FROM: NRC 2012; AGRIACCESS DATA 2013*
**TOTAL FIBER AND DOMINANT NSP TYPE PROFILE OF TYPICAL CORN SOY DIET (PHIL. SAMPLE)**

ex: broiler starter ration

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
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</thead>
<tbody>
<tr>
<td>NDF %</td>
<td>20.2</td>
</tr>
<tr>
<td>ADF</td>
<td>7.1</td>
</tr>
<tr>
<td>cellulose</td>
<td>4.9</td>
</tr>
<tr>
<td>lignin*</td>
<td>2.2</td>
</tr>
<tr>
<td>HC</td>
<td>13.1</td>
</tr>
<tr>
<td>xylan</td>
<td>6.6</td>
</tr>
<tr>
<td>glucan</td>
<td>2.4</td>
</tr>
<tr>
<td>mannan (lin.)</td>
<td>2.2</td>
</tr>
<tr>
<td>others</td>
<td>1.9</td>
</tr>
</tbody>
</table>

*Crude Fiber in proximate analysis represents only lignin + a portion of cellulose or about 1/5 of true total fiber*

**AGRIaccess/TLCP data 2013**
HIGH FIBER HAS BEEN IDENTIFIED AS A MAJOR NUTRITIONAL CAUSE OF REDUCED PERFORMANCE IN MONOGASTRICS

PIGS AND POULTRY CAN ONLY TOLERATE THE MAXIMUM OF 15% TOTAL FIBER (compared to 5-8% min) BECAUSE OF INHERENTLY LIMITED GUT SPACE AND EXPANSIVE CHARACTER OF FIBERS. (Typical Phil. Corn-soy rations already have more than enough total fiber of 14-24%.)

MYTH pigs and poultry need more fiber for better digestion and gut health
Fibers absorb up to 5 times their weight in water, resulting in multifold expansion in fiber mass & volume, restricting available gut space and nutrient solubility – very critical in birds due to relatively smaller gut space.

Up to 40% of plant proteins are trapped in the fiber matrix, rendering them unavailable.

Fibers increase digesta viscosity – negatively affecting absorbability of all other nutrients.
IN THE ACTUAL INGREDIENT, FIBERS EXIST IN AN
INTERLOCKING AND LAYERED MATRIX OF \( b \)
LINKED SACHARRIDES, WITH PROTEINS AND
OTHER MATERIALS TRAPPED WITHIN

(*lab substrates are purified forms i.e. cellulose, xylan, glucan)
Molecular view of Xylan and cellulose complex in grains showing 3D physical, geometric and surface characteristics, and trapping of proteins and other nutrients inside fiber matrix.
X-ray picture of betagalactomannan + cellulose fiber matrix showing the interlocking and layered fiber matrix and the trapped nutrients therein
INDICATIVE CAUSE #2

LOW PROTEIN BIOLOGIC VALUE (BV) OF PLANT PROTEINS (<50%) IN MONOGASTRICS Aamink et al; Lawlor et.al., among others

USE OF SYNTHETIC AMINO ACIDS TO INCREASE BV IS PHYSIOLOGICALLY LIMITED BY THRESHOLD EFFECT (BELL CURVE PHENOMENON IN BIOLOGICAL SYSTEMS)
SCIENCE BASED SOLUTION

ATTACK PROBLEM AT THE ROOT

FIBER DIGESTIBILITY
MANURE PRODUCTION

TARGETED ENZYMES
FEED ENZYMES

Understanding enzymes
Separating myths/anecdotes from facts
ENZYMES = LIFE

ENABLES ALL BIO-REACTIONS IN AN ORGANISM,

FROM BASIC OXYGEN-CO2 EXCHANGE ➔

TO BREAKDOWN OF COMPLEX MATERIALS ➔

TO UTILIZATION AND ACCRETION/DEPOSITION (MUSCLE, FAT, ORGAN, BONES, ETC) ➔

TO DISPOSAL OF METABOLIC/WASTE BY PRODUCTS
DIGESTIVE ENZYMES – BREAK DOWN COMPLEX FOOD TO SIMPLER FORMS UTILIZABLE BY THE BODY

PROTEINS $\rightarrow$ PEPTIDES TO AMINOACIDS

POLYSACCHARIDES (STARCH & FIBERS) $\rightarrow$ TO SIMPLE SUGARS (GLUCOSE)

FATS/LIPIDS $\rightarrow$ FATTY ACIDS

ENZYME NAMES END IN “ase” as in protease, lipase, lactase
THE BASIC NATURE OF FEED ENZYMES

ORIGIN

BIOLOGIC ACTIVITY

PHYSIOLOGIC FUNCTION

DOSE AND EFFECT RELATIONSHIP
MICROBIAL ORIGIN

BACTERIAL - *Bacillus* sp, TRANSGENIC *E. coli*

BIOLOGIC TYPE OF ACTIVITY

ENZYME SPECIFICITY – TEMPLATE TYPE enzyme-substrate REACTION

“LOCK & KEY”

SIMILAR TO Ab-Ag interaction in vaccines and most antibiotic-bacterial interaction
Specificity is imparted by the template mechanism of activity.
PHYSIOLOGIC FUNCTION

ENZYME ACTIVITY GOVERNED/CONTROLLED BY

GASTRIC/INTESTINAL PH

INTESTINAL LUMINAL AREA & MOTILITY

SOLUBILITY

EXPOSURE TIME – EFFECTIVE INTESTINAL ABSORPTION TIME IS FINITE

GUT ACTIVE - unabsorbed, unstored, require continuous treatment of feed
DOSE AND EFFECT RELATIONSHIP

Follows the dose-response curves typical of a biologic setting (Bell curve phenomenon)

**DOSING** must follow the indicative enzyme unit: Target substrate and the finite transit time thru the digestive environment

**MYTH** a general dosing regimen will ensure enzyme activity across all levels

General dosing is inappropriate as enzyme dose must correspond to substrate level in target feed
CLEARLY, **ENZYMES ARE BIOLOGICALS**, NOT SUPPLEMENTS

ENZYMES **MUST NOT** BE TREATED AS REGULAR SUPPLEMENTS LIKE VITAMINS
STANDARD MEASURE OF ENZYME DOSAGE AND ACTIVITY

One (1) enzyme Unit (u) is the quantity of enzyme which will catalyze the conversion of one (1) micromole (umol) of substrate in one (1) minute under specified conditions.

Ex. One (1) u of cellulase will break down one (1) umol of cellulose per minute under specified conditions.

*Per IUB nomenclature*
FEED ENZYMES CURRENTLY IN USE

ACCORDING TO NATURE
- **endogenous** – enzymes that the animals produce
  - protease, amylase, lipase
  - indicated for pigs below 18 days of age**
- **exogenous** – enzymes that animals do not produce
  - FIBER/NSP ENZYMES

ACCORDING TO PRODUCT CONTENT
- **traditional** - multi enzymes
- **targeted enzymes** – purified, single or combination
TRADITIONAL - MULTI ENZYMES

WHOLE PRODUCT OF ONE ORGANISM

CONTAINS MORE THAN 15 ENZYMES IN A PRODUCT, BOTH ENDOGENOUS & EXOGENOUS, INHERENTLY LIMITED INDIVIDUAL ENZYME QUANTITY AND ACTIVITY

DOSING TYPICALLY GENERAL

INTRODUCED IN THE 70’S

EX. HEMICELLULASES from Aspergillus sp.
contains >18 enzymes xylanase, amylase betagalactomannanase, b-glucanases +14 other endogenous and exogenous enzymes
TARGETED ENZYMES

ENZYMES/ENZYMES COMBINATIONS DESIGNED TO DIGEST SIGNIFICANT LEVELS OF MAJOR NSP OF SPECIFIC INGREDIENTS/BLENDS (i.e. copra meal, wheat, corn-soy rations)

SINGLE (xylanase, cellulase, betagalactomannanase, etc) or COMBINATIONS (xylanase+cellulase+betaglucanase or betagalactomammanase+cellulase, etc) OF PURIFIED ENZYME/S

MADE ECONOMICALLY FEASIBLE FOR LIVESTOCK FEEDING BY RECOMBINANT DNA TECHNIQUE (i.e. Transgenic E. coli )**

Purified Enzymes allow formulation of combination of enzymes designed to digest known fibers of target ingredients/rations in a quantifiable, measureable and visible effect – TAILOR FIT
AS FIBERS EXIST IN AN INTERLOCKING AND LAYERED MATRIX
AN APPROPRIATE COMBINATION OF ENZYMES AT THE RIGHT AMOUNT OF ENZYME UNITS ARE NECESSARY TO EFFECT THE DIGESTION UP TO THE INNER LAYERS OF THE FIBER

**MYTH**  The more kinds enzymes contained in a product the better
APPROPRIATE COMBINATION AND PROPER DOSING OF TARGETED ENZYME/S CAN DIGEST/RELEASE

- Up to 70% of the hemicellulose fiber
- Up to 40% of the cellulose
- Up to 75% of the protein trapped in the fibers
- Up to 65% of the phytate

In a typical monogastic digestive transit time (mouth to ileum)

*NRC 2012; AGRIaccess data 2004-2013*
KEY TO ENZYME TREATMENT OF CORN-SOY RATIONS**

THE RIGHT KIND OF ENZYME/S AT THE RIGHT AMOUNT OF ACTIVE UNITS

TARGETED ENZYMES
WHAT WILL TARGETED ENZYMES DELIVER
MARKED DIGESTIBILITY GAINS

>10%-60% DIGESTIBILITY IMPROVEMENT >>
BETTER PROTEIN AND ENERGY AVAILABILITY >>>
LESSER FEED INTAKE NEEDED TO SATISFY ENERGY
REQUIREMENT >>>> SIMILAR OR BETTER
PRODUCTION PERFORMANCE AT 8-11% BETTER
FCR

“AN ANIMAL EATS TO SATISFY ITS ENERGY
REQUIREMENT”

MYTH the animal needs to eat more to grow
more
INCREASED UTILIZATION OF CHEAPER, LOCALLY AVAILABLE AGRICULTURAL BY PRODUCTS AND NON-TRADITIONALS

COPRA MEAL
RICE BRAN
PALM KERNEL MEAL
POLLARD
CASSAVA MEAL
WHEAT
DDGS

FROM TRADITIONAL 5% MAX TO >20% INCORPORATION RATE WITHOUT THE USUAL NEGATIVE PERFORMANCE IMPACT

= LOWER DIRECT FEED COSTS BY 8-14%
REDUCTION IN FEED COSTS/GAIN

significantly better FCR and resulting lower feed costs/gain by 8-11%

*LOWER FEED INTAKE (8%-12%) AT SIMILAR OR BETTER PERFORMANCE - A CONSISTENT FEATURE OF APPROPRIATE & EFFECTIVE ENZYME TREATMENT**
## SUMMARY OF RESULTS COMMERCIAL TRIALS BROILER  TARGETED ENZYME*

<table>
<thead>
<tr>
<th>ITEM</th>
<th># BARNs</th>
<th># BIRDS</th>
<th>DAYS TO MORTALITY</th>
<th>HARVESTED</th>
<th>TOTAL WT</th>
<th>AVE. LW/HD</th>
<th>TOTAL FEED</th>
<th>FCR</th>
<th>COST/KG</th>
<th>FEED COST/BIRD</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRADITIONAL</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>UNTREATED</td>
<td>4</td>
<td>18,464</td>
<td>36</td>
<td>1226</td>
<td>17,238</td>
<td>29,478</td>
<td>1.710</td>
<td>57,960</td>
<td>1.97</td>
<td>49.94</td>
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<tr>
<td>ALKACEL</td>
<td>4</td>
<td>18,608</td>
<td>36</td>
<td>987</td>
<td>17,621</td>
<td>30,061</td>
<td>1.706</td>
<td>53,250</td>
<td>1.77</td>
<td>45.56</td>
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<tr>
<td>Diff.</td>
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<td>-239</td>
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<td></td>
<td></td>
<td>-0.004</td>
<td>-4710</td>
<td>0.004</td>
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<tr>
<td>% Diff</td>
<td></td>
<td>-19.49</td>
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<td></td>
<td></td>
<td></td>
<td>-0.23</td>
<td>-8.13</td>
<td>-2.20</td>
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<tr>
<td>COOL CELL *</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>UNTREATED</td>
<td>1</td>
<td>32,764</td>
<td>35</td>
<td>1217</td>
<td>31,547</td>
<td>53,000</td>
<td>1.680</td>
<td>82,750</td>
<td>1.561</td>
<td>39,033</td>
</tr>
<tr>
<td>ALKACEL</td>
<td>1</td>
<td>32,561</td>
<td>32</td>
<td>1108</td>
<td>31,453</td>
<td>51,649</td>
<td>1.642</td>
<td>73,100</td>
<td>1.415</td>
<td>36,833</td>
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<td>-0.038</td>
<td>-9650</td>
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<tr>
<td>% Diff</td>
<td></td>
<td>-8.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-2.26</td>
<td>-11.66</td>
<td>-5.64</td>
</tr>
</tbody>
</table>

TRADITIONAL BUILDINGS, OPEN ELEVATED WOOD SLATS AND MANUAL FEEDERS AND WATERERS

COOL CELL TEMPERATURE & HUMIDITY CONTROLLED BUILDINGS, ELEVATED PLASTIC SLATS, AUTOMATED FEEDERS AND WATERERS

BOTH FARMS ON COMMERCIAL FEED AND COMMERCIAL CHICKS

*1.6KG WEIGHT CAP TARGET OF COOL CELL FARM

ALKACEL 20X WS DOSE AT 5GM/10LT DRINKING WATER CONTINUOUSLY 24/7

ALKACEL WS TREATMENT COST (1peso/bird) INCLUDED IN FEED COST COMPUTATION

ALKACEL 20X WS TREATED BIRDS SHOW MORE OR LESS SIMILAR ADGs WITH UNTREATED BIRDS BUT ON 8-11% LOWER FEED CONSUMED, LEADING TO 9-10% BETTER FCR, 5-8% LOWER FEED COST/KG WEIGHT GAIN AND 7-9% LOWER FEED COST/BIRD, WITH 8-19% LOWER MORTALITY MANURE OF TREATED BIRDS ARE VISUALLY MORE OR LESS 1/3 SMALLER AND DRIER

*(ALKACEL 20X WS ²)*
VERY SUBSTANTIAL REDUCTION IN MANURE AND OTHER POLLUTIVE EFFECTS ON ENVIRONMENT

REDUCTION OF MANURE VOLUME BY UP TO 35%

REDUCTION OF NITROGEN EXCRETION AND RESULTING BARN AMMONIA AND FARM ODORS

REDUCTION OF MANURE DISPOSAL AND ODOR MITIGATION COSTS
### SUMMARY RESULTS BROILERS
35 day feeding, Commercial Rations, Targeted Enzyme * Treatment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control no enzyme</th>
<th>T1 1tsp/10lt</th>
<th>Sig.</th>
<th>T2 1.5tsp/10lt</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wt. gain, gms</td>
<td>1.612</td>
<td>1.640</td>
<td>ns</td>
<td>1.662</td>
<td>ns</td>
</tr>
<tr>
<td>Feed Consumption, gms</td>
<td>3.184</td>
<td>2.915</td>
<td>s</td>
<td>3.006</td>
<td>ns</td>
</tr>
<tr>
<td>FCR</td>
<td>1.95</td>
<td>1.78</td>
<td>s</td>
<td>1.81</td>
<td>s</td>
</tr>
<tr>
<td>Manure Profile</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Total manure, airdry, gms</td>
<td><strong>1,136</strong></td>
<td><strong>904</strong></td>
<td><strong>s</strong></td>
<td><strong>922</strong></td>
<td><strong>s</strong></td>
</tr>
<tr>
<td>Booster manure NSP %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDF</td>
<td>40.88</td>
<td>29.63</td>
<td><strong>s</strong></td>
<td>28.47</td>
<td><strong>s</strong></td>
</tr>
<tr>
<td>ADF</td>
<td>14.74</td>
<td>9.33</td>
<td><strong>s</strong></td>
<td>9.28</td>
<td><strong>s</strong></td>
</tr>
<tr>
<td>HC</td>
<td>26.14</td>
<td>20.30</td>
<td><strong>s</strong></td>
<td>19.19</td>
<td><strong>s</strong></td>
</tr>
<tr>
<td>Starter manure NSP %</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>NDF</td>
<td>38.31</td>
<td>27.85</td>
<td><strong>s</strong></td>
<td>25.58</td>
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<tr>
<td>ADF</td>
<td>15.69</td>
<td>9.77</td>
<td><strong>s</strong></td>
<td>9.31</td>
<td><strong>s</strong></td>
</tr>
<tr>
<td>HC</td>
<td>22.62</td>
<td>18.08</td>
<td><strong>s</strong></td>
<td>16.27</td>
<td><strong>s</strong></td>
</tr>
<tr>
<td>Finisher manure NSP %</td>
<td></td>
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</tr>
<tr>
<td>NDF</td>
<td><strong>36.24</strong></td>
<td><strong>25.40</strong></td>
<td><strong>s</strong></td>
<td><strong>26.47</strong></td>
<td><strong>s</strong></td>
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<tr>
<td>ADF</td>
<td>13.26</td>
<td>7.72</td>
<td><strong>s</strong></td>
<td>9.38</td>
<td><strong>s</strong></td>
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<tr>
<td>HC</td>
<td>22.98</td>
<td>17.68</td>
<td><strong>s</strong></td>
<td>17.09</td>
<td><strong>s</strong></td>
</tr>
</tbody>
</table>

ns not significant  s significant  NDF Neutral Detergent Fiber /Total Fiber  ADF Acid Detergent Fiber/cellulose + lignin  HC hemicellulose

*Growth Performance and Manure Profile of Broilers Supplemented with Alkacel 20X WS Enzyme. 2010. CVM, CLSU, Munoz, NE, PHIL.*
TYPICAL CORN SOY PIG FINISHER MANURE

large and wet due to high levels of water absorbing fiber (NDF>20%) and undigested material
MANURE FROM TARGETED ENZYME TREATED RATIONS
Small Compact dry with low undigested material
BROILER MANURE UNTREATED

BROILER MANURE TARGETED ENZYME TREATED (ALKACEL 20X®)
SMALLER, MORE COMPACT, DRIER
HOW WILL ONE KNOW THE ENZYME WORKS?

1. MANURE SIZE/VOLUME DECREASE
   true representative of feed digestibility
   immediately observable measure of enzyme activity

2. LABORATORY verification
   quantification of fibers digested by comparison of
   feed pre feeding and manure NDF/ADF/HC levels
   accurate, easily quantified and qualified
determination of actual enzyme activity
3. PERFORMANCE IMPROVEMENTS
FCR, FEED INTAKE, ADG & HI related improvements (stress, morbidity/mortality).
FCR improvement typically comes with lower Feed Intake but with similar or slightly better ADG

Enzymes are not intended nor designed to improve ADG**

MYTH enzymes increase ADG

4. COST IMPROVEMENTS
reduced feed costs – direct cost/kg feed and cost/kg gain or unit production
manure disposal costs
IF AN ENZYME WORKS . . . . . . What to test for

IF A PROTEASE ENZYME WORKS
  THE AMOUNT OF RESIDUAL PROTEIN IN THE MANURE SHOULD SIGNIFICANTLY DECREASE

IF A FIBER (NSP) ENZYME WORKS
  THE AMOUNT OF RESIDUAL FIBER IN THE MANURE AND SIZE/VOLUME OF MANURE SHOULD SIGNIFICANTLY DECREASE

IF A PHYTASE WORKS
  THE AMOUNT OF PHOSPHATE IN THE MANURE SHOULD SIGNIFICANTLY DECREASE

IF AN ENZYME WORKS
  THE FEED INTAKE SHOULD SIGNIFICANTLY DECREASE AND FCR SHOULD IMPROVE
FOR THE INDUSTRY TO REALIZE THE FULL BENEFIT OF ENZYME TECHNOLOGY:

ENZYMES AND THEIR FEED APPLICATIONS MUST BE TECHNICALLY AND APPROPRIATELY UNDERSTOOD IN ORDER FOR FEED APPLICATIONS TO BE EFFECTIVELY FORMULATED AND IMPLEMENTED
IMAGINE

IF UP TO 30% OF THE MANURE FORMING MATERIALS CAN BE MADE DIGESTIBLE AND AVAILABLE TO THE ANIMAL

HOW MUCH FEED EFFICIENCY IMPROVEMENT, FEED COST SAVINGS AND MANURE EFFLUENT REDUCTION YOU CAN GENERATE!!!
TARGETED ENZYMES

THE MOST VERIFIABLE, COST EFFECTIVE APPROACH TO:

IMPROVE DIGESTIBILITY >60%

IMPROVE FCR >12%

REDUCE FEED COST >15%

REDUCE MANURE AND OTHER EFFLUENTS >35%
“TAILOR FIT” TO YOUR FORMULA/INGREDIENT FLEXIBILITY STRATEGY

AND FINALLY

ACHIEVE FULL USE OF FEED EFFICIENCY PERFORMANCE IMPROVEMENTS THE TECHNOLOGY IS INTENDED TO DELIVER

Cost to benefit Ratio 1:5
A TECHNICAL PRESENTATION OF:

AGRIaccess
Current Nutrition Technology Provider

TARGETED ENZYMES
MINERAL-AMINO ACID CHELATES

MAKE THE MOST OUT OF FEED!!!

Pls visit us: www.agriaccess.com