



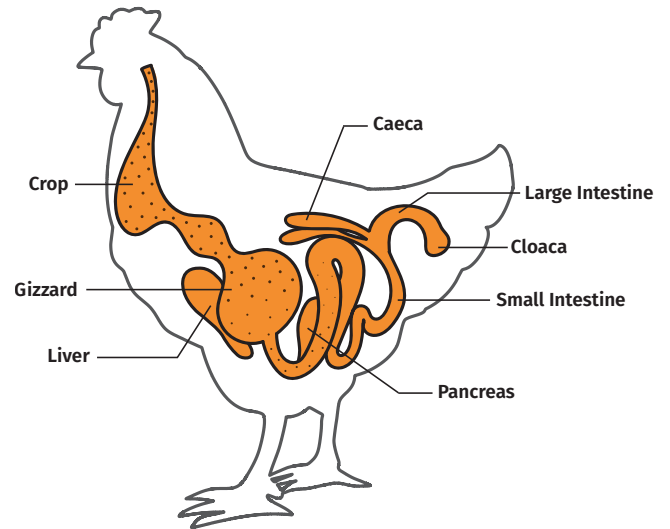
## Overview of Feed Enzymes

### ▶ What are digestive enzymes?

- Digestive enzymes break down feedstuffs to their basic components
- Secreted in the stomach and by the pancreas
- Intestinal enzymes include:
  - Proteases (protein)
  - Lipases (fats)
  - Amylases (starch)
  - Carbohydrases (sucrase, etc.)

### ▶ What are substrates?

- Substrates are found in feed ingredients and acted upon by the enzyme
- Substrates are broken into smaller pieces, more easily absorbed or utilized



| Substrate     | What do you get from that substrate?        |
|---------------|---|
| Protein       | Amino acids, peptides                       |
| Fats          | Fatty acids                                 |
| Starch        | Glucose (energy)                            |
| Carbohydrates | Smaller components -> Energy and prebiotics |
| Phytic acid   | Phosphorus                                  |

### ▶ Feed enzymes accomplish several objectives

- Increase and expand upon enzymes already present (phytase, amylase, protease)
- Supplement enzymes not already present (non-starch polysaccharide (NSP) enzymes)
- Improve ingredient digestibility
- Improve animal performance (growth and feed conversion rate)
- Improve environmental factors (litter quality, air quality)
- Reduce anti-nutritional factors
- Lower feed costs
  - Feed contributes 65%-70% or more of production costs

## Many Examples of Feed Enzymes Currently on the Market

| Enzyme              | Primary Target/Substrate and Source                            | Primary Product Produced      |
|---------------------|--|-------------------------------|
| Phytases            | Phytic acid from all plant ingredients                         | P, inositol                   |
| Proteases           | Protein from plant and animal ingredients                      | Amino acids, peptides         |
| Amylases            | Starch from cereals  | Glucose (energy)              |
| Xylanases           | Arabinoxylan from cereals (corn, wheat, etc.)                  | Xylo-oligomers                |
| Glucanases          | Glucans mainly from cereals                                    | B-linked oligosaccharides     |
| Pectinases          | Pectins from leguminous ingredients (SBM, canola, beans, etc.) | Galacturonic acids and others |
| Galactosidases      | Oligosaccharides in leguminous ingredients                     | Galactose, sucrose, others    |
| Cellulases          | Cellulose in all plant ingredients                             | Oligomers and glucose         |
| Debranching enzymes | Ancillary components attached to NSPs in plants                | Improved NSP enzyme efficacy  |

## Feed Enzymes Can Have Primary and Secondary Nutritional Uplifts

| Enzyme      | P | Ca | Trace Minerals | Energy | Amino Acids |
|-------------|---|----|----------------|--------|-------------|
| Phytases    | 1 | 2  | 2              | 2      | 2           |
| NSP Enzymes |   |    |                | 1      | 2           |
| Proteases   |   |    |                | 2      | 1           |
| Amylases    |   |    |                | 1      |             |

1 = Primary Effect

2 = Secondary Effect