Introduction

Welcome to Feed Formulation Pro

Feed Formulation Pro is a professional-grade least-cost feed formulation software designed for poultry and livestock nutritionists. The application uses **WPSA** (World's Poultry Science Association) energy calculations and **SID** (Standardized Ileal Digestible) amino acid values for precise nutrition.

Key Features

- **77 Ingredients** across 5 major categories
- **WPSA-based AMEn** (Apparent Metabolizable Energy) calculations
- **SID Amino Acid** digestibility coefficients
- **Strain-specific nutrient requirements**: Ross, Cobb, Aviagen, Amino Chick, Dynamic Model
- **Light/Dark Mode Interface** for comfortable viewing
- **Linear Programming Optimizer** for least-cost formulations
- **Real-time nutrient analysis** and cost calculations

Who Should Use This Software?

- Poultry nutritionists
- Livestock feed formulators
- Animal nutrition students and researchers
- Feed mill operators
- Veterinarians specializing in nutrition

Application Overview

Main Interface Sections

A) Top Header

The top header contains the main controls for your formulation work:

- **Application Title**: “Feed Formulation Pro” - Always visible for reference
- **Strain Selector**: Choose between Ross, Cobb, Aviagen, Amino Chick, or Dynamic Model
- **Theme Toggle**: Switch between Light and Dark mode for your viewing preference
- **Reset Button**: Clear all selections and constraints to start a fresh formulation
- **Calculate Button**: Run the linear programming optimization algorithm

B) Left Panel - Ingredient Selection

The left panel is your ingredient library:

Category Tabs: Switch between different ingredient categories

- Grains
- Plant By-Products
- Animal Sources
- Fats & Oils
- Supplements & Additives
- **Ingredient Cards**: Click any ingredient to add it to your formulation
- **Min/Max Constraints**: Set minimum and maximum inclusion percentages
- **Price Entry**: Enter current market prices per kilogram

C) Center Panel - Nutrients

The center panel displays all nutritional requirements:

- View complete nutrient specifications
- Set minimum values (lower bounds)
- Set maximum values (upper bounds)

- Includes:
- Proximate analysis (DM, CP, EE, CF, Ash)
- Energy (AMEn-WPSA in kcal/kg)
- All 9 SID amino acids
- Major minerals (Ca, P, avP, Na, K, Cl)
- Essential vitamins and trace minerals

D) Right Panel - Results

The right panel shows your formulation output:

- **Formula Composition**: Ingredient percentages in the optimized diet
- **Nutrient Analysis**: Complete nutritional breakdown of the final formula
- **Cost Per Kg**: Total cost calculation based on ingredient prices
- **Constraint Status**: Visual indicators showing if constraints are met

Ingredient Categories

Overview: 77 Total Ingredients

Feed Formulation Pro includes a comprehensive library of 77 ingredients carefully selected for poultry and livestock nutrition.

1. Grains (14 Items)

Grains are the primary energy sources and form the foundation of any diet.

#	Ingredient	Crude Protein %	Recommended Max %
1	Corn	7.42	70%
2	Wheat	11.50	50%
3	Barley	10.80	40%
4	Oats	11.30	20%
5	Rye	10.50	15%
6	Rice	7.50	30%
7	Soybean full fat, Extruded	36.0	25%
8	Soybean full fat, Roasted	37.0	25%

9	Linseeds	22.0	10%
10	Peas	22.0	20%
11	Sorghum, Low Tannin	9.0	50%
12	Sorghum, High Tannin	9.5	30%
13	Millet, Pearl	11.0	30%
14	Triticale	11.8	40%

Usage Notes:

- **Corn** is the gold standard energy source with excellent palatability
- **Wheat** provides good energy and slightly higher protein than corn
- **Barley** contains beta-glucans; limit inclusion to avoid viscosity issues
- **Rye** has anti-nutritional factors; keep below 15%
- **Full-fat soybeans** provide both energy and protein but must be heat-treated

2. Plant By-Products (32 Items)

Protein sources, fiber sources, and co-products from grain processing.

Major Protein Sources:

Ingredient	Crude Protein %	Notes
Soybean Meal	44.0	Industry standard, excellent amino acid profile
Sunflower Meal, partially dehulled	34.0	High fiber, lower lysine
Sunflower Meal, non-dehulled	28.0	Very high fiber
Soy Protein Concentrate (SPC)	65.0	Premium protein source, low ANF
Rapeseed Meal	34.0	Watch glucosinolates
Canola Meal	36.0	Low glucosinolates variety
Cottonseed Meal, Expeller	38.0	Free gossypol concern
Cottonseed Meal, Solvent	41.0	Higher protein extraction
Peanut Meal	45.0	Watch aflatoxin contamination
Sesame Seed Meal	42.0	Good methionine content

Grain By-Products:

Ingredient	Crude Protein %	Primary Use
Corn Gluten Meal	60.0	High protein, excellent pigmentation
DDGS, Corn	27.0	Energy and protein, limit to 15%

Corn Gluten Feed	21.0	Moderate protein, high fiber
Wheat Gluten Meal	80.0	Very high protein concentrate
DDGS, Wheat	32.0	Higher protein than corn DDGS
Wheat Middlings	16.0	Moderate fiber, good palatability
Rice Bran	13.0	Fat source, watch rancidity

Fiber Sources:

- Wheat Bran (15% CP)
- Rice Hulls (3% CP)
- Soy Hulls (12% CP)
- Alfalfa Meal (17% CP)

Other By-Products:

- Palm Kernel Meal (16% CP)
- Guar Meal (42% CP)
- Safflower Meal (22% CP)
- Date Palm Seeds (5.5% CP)

- Molasses, Beet (8% CP)
- Molasses, Sugarcane (4% CP)
- Noodle Byproduct (12% CP)
- Corn Bran (9% CP)
- Corn Germ Meal (20% CP)
- Corn Germ (12% CP)
- Wheat Flour (11% CP)

3. Animal Sources (3 Items)

High-quality protein and mineral sources.

Ingredient	Crude Protein %	Calcium %	Phosphorus %	Max Inclusion
Fish Meal 65%	65.0	4.5	2.9	5%
Meat and Bone Meal	50.0	10.0	5.0	5%
Poultry By-Product Meal	60.0	4.0	2.2	8%

Usage Notes:

- Excellent amino acid balance, especially lysine and methionine
- High digestibility
- Watch for oxidation in storage
- May affect meat/egg flavor at high levels
- Verify BSE-free status and regulatory compliance

4. Fats & Oils (3 Items)

Concentrated energy sources for high-energy diets.

Ingredient	Ether Extract %	Calcium %	ME (kcal/kg)	Linoleic Acid %
Oil	99.0	0	8500	50
Fat, Crystalline	99.0	0	8500	12
Fat, Calcium Salt	84.0	9.0	7400	10

Usage Notes:

- **Oil**: Liquid vegetable oils (soybean, sunflower, corn) - highest energy and linoleic acid

- **Fat, Crystalline**: Saturated animal fats - stable, low oxidation risk
- **Fat, Calcium Salt**: Protected fat for ruminants, can be used in poultry
- Typical inclusion: 2-6% of diet
- Improves pellet quality and reduces dust
- Watch for oxidation - use antioxidants

5. Supplements & Additives (25 Items)

Synthetic Amino Acids:

Amino Acid	Purity %	Typical Inclusion	Purpose
DL-Methionine	99%	0.1-0.3%	First limiting AA in corn-soy diets
L-Lysine-HCl	78%	0.2-0.5%	Second limiting AA
L-Lysine-Sulfate	51%	0.3-0.7%	Alternative lysine source
L-Threonine	98.5%	0.05-0.15%	Third limiting AA
L-Tryptophan	98%	0.01-0.05%	Fourth limiting AA, behavior
L-Valine	98%	0.02-0.08%	BCAA, important for growth

L-Isoleucine	98%	0.02-0.06%	BCAA, often co-limiting with valine
L-Arginine	98%	0.05-0.15%	Immune function, growth

Mineral Sources:

Mineral	Calcium %	Phosphorus %	Other	Usage
Di Calcium Phosphate (DCP)	23	18.5	-	Ca & P source
Mono Calcium Phosphate (MCP)	16	22	-	High P source
Calcium Carbonate	38	-	-	Ca source
Limestone	38	-	-	Ca source, particle size important
Sodium Bicarbonate	-	-	27% Na	Na source, buffer
Potassium Carbonate	-	-	56.5% K	K source, buffer
NaCl (Salt)	-	-	39% Na, 60% Cl	Na & Cl source
Potassium Chloride	-	-	52% K, 47% Cl	K & Cl source
Ammonium Chloride	-	-	66% Cl	Cl source, urinary acidifier
Choline Chloride	-	-	25% Cl	Choline & Cl source

Additives:

- **Vit-Min Premix**: Complete vitamin and trace mineral package (0.25-0.5%)
- **Bentonite**: Binder, toxin binder, anti-caking (0.5-2%)
- **Toxin Binder**: Mycotoxin adsorbent (0.1-0.3%)
- **Phytase**: Enzyme for phytate phosphorus release (0.01-0.02%)
- **Probiotic**: Beneficial bacteria for gut health (0.01-0.05%)
- **Acidifier**: pH reduction, pathogen control (0.1-0.3%)
- **Filler**: Balance formulation to 100% (as needed)

Nutrients & SID Amino Acids

Proximate Analysis

Dry Matter (DM) %

- Represents non-water content
- Typically 88-92% in complete feeds
- Important for accurate nutrient calculations

Crude Protein (CP) %

- Nitrogen content × 6.25
- Does not indicate amino acid quality
- Broilers: 18-23% depending on age
- Layers: 15-17%

Ether Extract (EE) %

- Fat content of the diet
- Provides 2.25× more energy than carbohydrates
- Typical range: 3-8%

Crude Fiber (CF) %

- Indigestible carbohydrate fraction
- Keep low in poultry diets: 2.5-4%
- Higher levels reduce energy density

Ash %

- Mineral content of the diet
- Typical range: 4-7%
- Higher in layer diets due to calcium needs

Energy

AMEn-WPSA (kcal/kg)

Apparent Metabolizable Energy, corrected for nitrogen

Calculated using WPSA formulas that consider: - Crude protein - Ether extract - Crude fiber - Nitrogen-free extract

Typical values: - Broiler Starter: 2900-3050 kcal/kg - Broiler Grower: 3000-3150 kcal/kg - Broiler Finisher: 3100-3250 kcal/kg - Layers: 2700-2850 kcal/kg

SID Amino Acids

SID = Standardized Ileal Digestible

SID values represent the amino acids actually absorbed by the bird, accounting for: - True digestibility - Endogenous losses (standardized) - More accurate than total amino acids

Essential Amino Acids:

Amino Acid	Broiler Starter	Broiler Finisher	Layer	Function
Lysine	1.28%	1.03%	0.75%	Growth, feathering, body protein synthesis
Methionine	0.51%	0.41%	0.38%	Protein synthesis, feather growth, donor of methyl groups

Met+Cys	0.95%	0.77%	0.68%	Sulfur amino acids, feather keratin
Threonine	0.86%	0.69%	0.58%	Mucin production, gut health, maintenance
Tryptophan	0.21%	0.17%	0.17%	Serotonin precursor, behavior, growth
Arginine	1.37%	1.10%	0.75%	Immune function, nitric oxide, growth
Isoleucine	0.86%	0.69%	0.62%	Branched-chain AA, protein synthesis
Leucine	1.28%	1.03%	0.85%	Branched-chain AA, mTOR signaling
Valine	0.96%	0.77%	0.70%	Branched-chain AA, co-limiting with Ile

Amino Acid Ratios:

All amino acids are often expressed as a ratio to lysine (lysine = 100):

- Methionine: 40-42% of lysine
- Met+Cys: 72-75% of lysine

- Threonine: 65-67% of lysine
- Tryptophan: 16-18% of lysine
- Arginine: 105-108% of lysine
- Valine: 75-77% of lysine
- Isoleucine: 67-70% of lysine

Minerals

Macro Minerals:

Calcium (Ca) % - Bone development, eggshell formation - Broilers: 0.85-1.0% - Layers: 3.8-4.5% - Must balance with phosphorus

Total Phosphorus (P) % - Broilers: 0.65-0.75% - Layers: 0.60-0.70% - Much is bound as phytate

Available Phosphorus (avP) % - Non-phytate P, readily absorbed - Broilers: 0.40-0.50% - Layers: 0.32-0.40% - Use phytase to release phytate P

Sodium (Na) % - Electrolyte balance, nutrient transport - Typical: 0.16-0.20% - Interacts with K and Cl

Potassium (K) % - Electrolyte balance, osmotic pressure - Typical: 0.60-0.90% - High in plant ingredients

Chloride (Cl) % - Electrolyte balance, acid-base status - Typical: 0.16-0.25% - Balance Na-K-Cl for DEB

Dietary Electrolyte Balance (DEB):

DEB (mEq/kg) = (Na × 434.98) + (K × 255.74) - (Cl × 282.06)

Optimal DEB: - Broilers: 200-250 mEq/kg - Layers: 150-250 mEq/kg

Trace Minerals:

- **Iron (Fe)**: 40-80 mg/kg
- **Copper (Cu)**: 8-12 mg/kg
- **Zinc (Zn)**: 40-100 mg/kg
- **Manganese (Mn)**: 60-100 mg/kg
- **Selenium (Se)**: 0.15-0.30 mg/kg
- **Iodine (I)**: 0.35-0.70 mg/kg

Vitamins

Fat-Soluble:

- **Vitamin A**: 8,000-12,000 IU/kg
- **Vitamin D3**: 2,500-4,000 IU/kg
- **Vitamin E**: 10-50 IU/kg
- **Vitamin K**: 2-4 mg/kg

Water-Soluble:

- **B-vitamins**: Included in premix
- Thiamin, Riboflavin, Niacin, Pantothenic acid, Pyridoxine, Biotin, Folic acid, B12
- **Choline**: 1200-1800 mg/kg

Formulating Diets by Animal Type

A) Broiler Chickens

Starter Phase (0-10 days)

Nutrient Specifications:

Nutrient	Minimum	Maximum
AMEn	2950 kcal/kg	3050 kcal/kg
Crude Protein	22.0%	23.5%
Lysine SID	1.28%	1.35%
Methionine SID	0.51%	0.56%
Met+Cys SID	0.95%	1.02%
Threonine SID	0.86%	0.92%
Tryptophan SID	0.21%	0.24%
Calcium	0.96%	1.05%
Avail. Phosphorus	0.48%	0.52%

Typical Formulation: - Corn: 52-58% - Soybean Meal: 35-40% - Oil: 2-4% - DCP: 1.8-2.0% - Limestone: 1.0-1.2% - Synthetic AA: As needed - Premix: 0.5%

Grower Phase (11-24 days)

Nutrient Specifications:

Nutrient	Minimum	Maximum
AMEn	3050 kcal/kg	3150 kcal/kg
Crude Protein	20.0%	21.5%
Lysine SID	1.15%	1.22%
Methionine SID	0.46%	0.51%
Met+Cys SID	0.85%	0.92%
Threonine SID	0.77%	0.83%
Tryptophan SID	0.19%	0.22%
Calcium	0.87%	0.96%
Avail. Phosphorus	0.44%	0.48%

Typical Formulation: - Corn: 56-62% - Soybean Meal: 30-35% - Oil: 3-5% - DCP: 1.6-1.8% - Limestone: 1.0-1.2% - Synthetic AA: As needed - Premix: 0.5%

Finisher Phase (25+ days)

Nutrient Specifications:

Nutrient	Minimum	Maximum
AMEn	3150 kcal/kg	3250 kcal/kg
Crude Protein	18.0%	19.5%
Lysine SID	1.03%	1.10%
Methionine SID	0.41%	0.46%
Met+Cys SID	0.77%	0.83%
Threonine SID	0.69%	0.75%
Tryptophan SID	0.17%	0.20%
Calcium	0.78%	0.87%
Avail. Phosphorus	0.39%	0.43%

Typical Formulation: - Corn: 60-66% - Soybean Meal: 25-30% - Oil: 4-6% - DCP: 1.4-1.6% - Limestone: 0.9-1.1% - Synthetic AA: As needed - Premix: 0.5%

B) Layer Hens

Production Phase (19+ weeks)

Nutrient Specifications:

Nutrient	Minimum	Maximum

AMEn	2750 kcal/kg	2850 kcal/kg
Crude Protein	16.0%	17.5%
Lysine SID	0.75%	0.82%
Methionine SID	0.38%	0.43%
Met+Cys SID	0.68%	0.75%
Threonine SID	0.58%	0.64%
Tryptophan SID	0.17%	0.20%
Calcium	3.80%	4.20%
Avail. Phosphorus	0.32%	0.40%
Sodium	0.16%	0.20%
Linoleic Acid	1.50%	2.50%

Typical Formulation: - Corn: 60-65% - Soybean Meal: 20-25% - Limestone: 8-10% - DCP: 1.2-1.5% - Oil: 1-2% - Salt: 0.3% - Synthetic AA: As needed - Premix: 0.5%

Special Considerations: - Calcium particle size: Use 50% limestone as coarse particles (2-4 mm) - Provide calcium in afternoon feeding for overnight shell formation - Monitor eggshell quality and adjust Ca levels - Adequate vitamin D3 for calcium absorption

C) Broiler Breeders

Production Phase

Nutrient Specifications:

Nutrient	Minimum	Maximum
AMEn	2800 kcal/kg	2900 kcal/kg
Crude Protein	15.0%	16.5%
Lysine SID	0.72%	0.80%
Methionine SID	0.36%	0.42%
Met+Cys SID	0.64%	0.72%
Calcium	3.20%	3.50%
Avail. Phosphorus	0.36%	0.42%
Linoleic Acid	1.20%	1.80%

Key Points: - Control energy to prevent overweight - Ensure adequate linoleic acid for fertility - Higher vitamin E for fertility (50-80 IU/kg) - Adequate selenium and vitamin A

D) Turkeys

Starter (0-4 weeks)

Nutrient Specifications:

Nutrient	Minimum	Maximum

AMEn	2850 kcal/kg	2950 kcal/kg
Crude Protein	28.0%	30.0%
Lysine SID	1.60%	1.70%
Methionine SID	0.55%	0.62%
Met+Cys SID	1.05%	1.15%
Calcium	1.20%	1.40%
Avail. Phosphorus	0.60%	0.70%

Grower (5-12 weeks)

Nutrient Specifications:

Nutrient	Minimum	Maximum
AMEn	3000 kcal/kg	3100 kcal/kg
Crude Protein	22.0%	24.0%
Lysine SID	1.30%	1.40%
Calcium	1.10%	1.30%
Avail. Phosphorus	0.50%	0.60%

Finisher (13+ weeks)

Nutrient Specifications:

Nutrient	Minimum	Maximum
AMEn	3100 kcal/kg	3200 kcal/kg
Crude Protein	18.0%	20.0%
Lysine SID	1.00%	1.10%
Calcium	0.90%	1.10%
Avail. Phosphorus	0.42%	0.50%

E) Swine

Starter (5-10 kg)

Nutrient Specifications:

Nutrient	Minimum	Maximum
DE	3400 kcal/kg	3500 kcal/kg
Crude Protein	20.0%	22.0%
Lysine SID	1.25%	1.35%
Calcium	0.70%	0.85%
Avail. Phosphorus	0.40%	0.50%

Grower (10-50 kg)

Nutrient Specifications:

Nutrient	Minimum	Maximum
DE	3300 kcal/kg	3400 kcal/kg
Crude Protein	17.0%	19.0%
Lysine SID	1.00%	1.10%
Calcium	0.65%	0.80%
Avail. Phosphorus	0.32%	0.40%

Finisher (50+ kg)

Nutrient Specifications:

Nutrient	Minimum	Maximum
DE	3250 kcal/kg	3350 kcal/kg
Crude Protein	15.0%	17.0%
Lysine SID	0.82%	0.90%
Calcium	0.60%	0.75%
Avail. Phosphorus	0.28%	0.35%

Using the Optimizer

How the Optimizer Works

Feed Formulation Pro uses **Linear Programming** (Simplex Algorithm) to find the least-cost diet that meets all your nutritional constraints.

The Mathematical Model:

Objective Function (Minimize):

```
Total Cost = Σ (Ingredient % × Price per kg)
```

Subject to Constraints:

```
Nutrient_min ≤ Σ (Ingredient % × Nutrient content) ≤ Nutrient_max
Ingredient_min ≤ Ingredient % ≤ Ingredient_max
Σ Ingredient % = 100%
```

Step-by-Step Formulation Process

Step 1: Select Your Strain

1. Click the **Strain Selector** dropdown in the top header

2. Choose from:

- **Ross**: Industry standard, high breast yield genetics
- **Cobb**: Fast growth rate, excellent feed conversion
- **Aviagen**: Premium meat quality focus
- **Amino Chick**: Alternative genetics
- **Dynamic Model**: Age-based polynomial nutrient calculations

The strain selection will automatically populate nutrient requirements based on research-backed specifications for that genetic line.

Step 2: Choose Ingredients

Click through the **Category Tabs** in the left panel:

- Start with **Grains** (your energy foundation)
- Add **Plant By-Products** (protein sources)
- Consider **Animal Sources** if allowed
- Add **Fats & Oils** for high-energy diets

- Include **Supplements & Additives** for balancing

Click ingredient cards to add them to your formulation

For each ingredient, set:

- **Minimum %**: Lower bound (usually 0%)
- **Maximum %**: Upper bound (use recommended limits)
- **Price per kg**: Current market price in your currency

Step 3: Set Nutrient Constraints

1. Navigate to the **Nutrients Panel** (center)
2. For each nutrient, enter:

- **Minimum value**: Lower bound (required level)
- **Maximum value**: Upper bound (optional, prevents excess)

3. Key nutrients to always constrain:

- AMEn-WPSA (energy)

- Crude Protein
- Lysine SID (most important AA)
- Methionine SID or Met+Cys SID
- Threonine SID
- Calcium
- Available Phosphorus

4. Optional constraints:

- Tryptophan, Arginine, Valine, Isoleucine, Leucine
- Sodium, Potassium, Chloride (for DEB)
- Crude Fiber (to limit)
- Linoleic Acid (for layers)

Step 4: Enter Prices

1. Update ingredient prices based on:

- Current local market prices

- Delivery costs
- Quality premiums
- Contract agreements

2. Ensure all selected ingredients have realistic prices

Step 5: Run Calculation

1. Click the **Calculate** button in the top header
2. The optimizer will run (usually takes 1-5 seconds)
3. Results will appear in the **Right Panel**

Step 6: Review Results

Formula Output: - Review ingredient inclusion percentages - Check if the formulation makes practical sense - Verify no single ingredient dominates excessively

Nutrient Analysis: - Compare achieved levels vs. requirements - Look for nutrients that are exactly at minimum (binding constraints) - Check for excessive nutrients (may indicate room for cost reduction)

Cost Analysis: - Review total cost per kg - Compare to target or previous formulations - Calculate cost per unit of production (e.g., cost per dozen eggs)

Step 7: Iterate and Refine

1. If cost is too high:

- Add more low-cost ingredients
- Relax non-critical nutrient constraints
- Allow higher maximum inclusion for cheap ingredients

2. If formulation is unbalanced:

- Tighten constraints on over-supplied nutrients
- Add more ingredient diversity
- Check for ingredient data accuracy

3. If optimization fails:

- Relax some constraints
- Add more ingredients
- Check for contradictory constraints

Troubleshooting

Error: “No Feasible Solution”

Causes: - Constraints are too tight and cannot be simultaneously satisfied - Not enough ingredients to meet all requirements - Contradictory minimum/maximum settings

Solutions: 1. Relax nutrient constraints by 2-5% 2. Add more ingredients to the formulation 3. Increase maximum inclusion limits 4. Check for errors in ingredient data 5. Remove some optional nutrient constraints 6. Verify amino acid ratios are achievable

High Cost Per Kg

Causes: - Too many expensive ingredients forced into the diet - Over-specification of nutrients - Tight constraints forcing premium ingredients

Solutions: 1. Allow more low-cost ingredients (corn, wheat) 2. Increase max inclusion for economical ingredients 3. Remove maximum limits on energy grains 4. Add alternative ingredients (DDGS, wheat bran) 5. Relax constraints on non-critical nutrients 6. Use more synthetic amino acids instead of high-protein meals

Unbalanced Formulation

Causes: - Missing key constraints - Ingredient data inaccuracies - Inappropriate min/max settings

Solutions: 1. Add constraints on major nutrients 2. Set maximum limits on all ingredients 3. Verify ingredient composition data 4. Use strain-specific requirements 5. Add constraints on fiber and ash

Optimizer Runs But Results Look Wrong

Causes: - Incorrect ingredient data - Wrong units (e.g., % vs. decimal) - Pricing errors

Solutions: 1. Double-check all ingredient nutrient values 2. Verify units are consistent 3. Check prices for decimal point errors 4. Compare results to known good formulations 5. Review ingredient min/max percentages

Best Practices

Before Optimization:

- ✓ Have realistic ingredient prices
- ✓ Use recent, accurate nutrient data
- ✓ Set appropriate ingredient limits
- ✓ Constrain all critical nutrients
- ✓ Choose the correct strain/age

During Optimization:

- ✓ Start with simple formulations

- ✓ Add complexity gradually
- ✓ Save successful formulations
- ✓ Document price changes

After Optimization:

- ✓ Verify results make sense
- ✓ Check for binding constraints
- ✓ Calculate shadow prices mentally
- ✓ Test formulation before full-scale production
- ✓ Monitor animal performance

Strain Presets

Understanding Genetic Differences

Modern poultry strains have been selectively bred for specific production goals, resulting in different nutrient requirements. Feed Formulation Pro includes requirement profiles for major genetic lines.

Available Strains

1. Ross (Aviagen Genetics)

Background: - World’s most widely used broiler strain - Bred for high breast meat yield - Excellent feed conversion ratio - Strong leg health

Key Characteristics: - Fast early growth - High breast yield (up to 80% of carcass) - Good livability - Suitable for various climates

Nutrient Recommendations: - Slightly higher lysine requirements for breast muscle development - Emphasis on balanced amino acid profile - Adequate calcium and phosphorus for skeletal support

Use Ross When: - Prioritizing breast meat production - Processing at 42-49 days - Market demands high breast yield

2. Cobb (Cobb-Vantress)

Background: - Second most popular broiler genetics globally - Bred for efficient growth and robustness - Excellent livability - Good adaptability

Key Characteristics: - Fast growth rate - Balanced body conformation - Excellent feed efficiency - Strong immune system

Nutrient Recommendations: - Moderate protein and energy levels - Focus on feed efficiency - Adequate antioxidants for health

Use Cobb When: - Seeking optimal feed conversion - Growing to heavier weights (>2.5 kg) - Working in challenging environments

3. Aviagen

Background: - Parent company of Ross, Arbor Acres, Indian River - Premium genetics for specialized markets - Focus on meat quality and welfare

Key Characteristics: - Superior meat quality - Good robustness - Balanced growth curve - Excellent leg strength

Nutrient Recommendations: - Emphasis on meat quality nutrients - Adequate vitamin E for oxidative stability - Balanced mineral profile

Use Aviagen When: - Premium market positioning - Focus on meat quality over quantity - Extended growing periods

4. Amino Chick

Background: - Alternative genetics for specific markets - Regional adaptation - Specialized applications

Key Characteristics: - Adapted to local conditions - Moderate growth rate - Good disease resistance

Nutrient Recommendations: - Standard nutrient specifications - Flexibility in ingredient selection - Practical formulation approach

Use Amino Chick When: - Working with these specific genetics - Regional requirements - Cost-effective production

5. Dynamic Model

Background: - Not a specific genetic line - Mathematical model for age-based nutrient requirements - Uses polynomial equations to calculate daily needs

Key Characteristics: - Age-specific recommendations (day by day) - Precise nutrient targeting - Minimizes over- or under-feeding - Based on published research models

Nutrient Calculation: The Dynamic Model calculates requirements based on:

```
Requirement (age) = a + b×age + c×age² + d×age³
```

Where coefficients (a, b, c, d) are research-derived values for each nutrient.

Use Dynamic Model When: - Formulating for specific ages - Optimizing nutrient density by week - Research or precision feeding applications - Working with multiple genetic lines

Switching Between Strains

How to Switch:

1. Click the **Strain Selector** dropdown
2. Select your desired strain
3. Nutrient requirements automatically update
4. Re-run **Calculate** to optimize

When to Switch:

- When changing genetics on your farm
- When formulating for different clients
- When comparing formulation costs across strains
- For educational/research purposes

Important Notes:

- Switching strains only affects nutrient requirements

- Ingredient library remains the same
- Your ingredient selections and prices are preserved
- Always recalculate after switching strains

Customizing Requirements

While strain presets provide excellent starting points, you may need to adjust based on:

Environmental factors:

- Hot climates: Increase energy density, reduce protein
- Cold climates: Increase energy requirements
- High altitude: Adjust for oxygen availability

Production goals:

- Faster growth: Increase protein and amino acids
- Better FCR: Optimize energy:protein ratio
- Improved livability: Adequate vitamins and minerals

Feed form:

- Mash: No adjustments needed
- Pellet: Can handle higher fiber, less fat needed
- Crumble: Between mash and pellet

Local regulations:

- Organic: No synthetic amino acids
- Antibiotic-free: Higher spec for immune support
- Non-GMO: Limited ingredient choices

To customize, simply adjust the nutrient min/max values in the Center Panel after selecting your base strain.

Tips & Best Practices

Ingredient Safety Limits

Always respect maximum inclusion levels to avoid anti-nutritional factors and imbalances:

Ingredient	Maximum Inclusion	Reason for Limit
Fish Meal	5%	Oxidation risk, flavor taint
Meat & Bone Meal	5%	Calcium imbalance, regulatory
Poultry By-Product Meal	8%	Ash content, quality variability
DDGS (Corn)	15%	Fiber, variability, mycotoxins
DDGS (Wheat)	12%	NSP, viscosity issues
Full-fat Soybean	25%	Must be properly heat-treated
Rye	15%	NSP, viscosity, anti-nutrients
Barley	40%	Beta-glucans, viscosity
Wheat	50%	Balance with other grains
Rapeseed Meal	10%	Glucosinolates
Sunflower Meal	15%	Fiber, low lysine
Cottonseed Meal	10%	Free gossypol
Rice Bran	15%	Rancidity, phytic acid

Synthetic Methionine	0.5%	Economic optimum
Synthetic Lysine	0.6%	Practical limit
Synthetic Threonine	0.3%	Balance consideration
Salt (NaCl)	0.4%	Toxicity risk
Limestone	10%	Except layers (up to 10%)

Formulation Strategies

Strategy 1: Corn-Soy Base (Standard)

Template: - Corn: 50-65% - Soybean Meal: 25-35% - Oil: 2-5% - Amino acids: Met, Lys, Thr - Minerals: DCP, Limestone, Salt - Premix: 0.5%

Advantages: - Predictable performance - High digestibility - Good palatability - Well-researched

Disadvantages: - Cost volatility - Limited flexibility - Commodity price exposure

Strategy 2: Multi-Grain Approach

Template: - Corn: 35-45% - Wheat: 20-30% - Barley or other grain: 10-15% - Soybean Meal: 20-28% - Oil: 2-4% - Enzyme (xylanase): 0.01% - Amino acids: As needed - Minerals and premix

Advantages: - Reduced price risk - Ingredient availability - Nutrient complementarity

Disadvantages: - More complex management - Variable viscosity - May need enzymes

Strategy 3: High By-Product Formulation

Template: - Corn: 40-50% - Wheat: 10-20% - DDGS: 10-15% - Soybean Meal: 15-20% - Sunflower Meal: 5-8% - Oil: 3-5% - Amino acids: Higher levels - Phytase: 0.01% - Minerals and premix

Advantages: - Lower cost - Use of co-products - Sustainable

Disadvantages: - Quality variability - Requires careful QC - May reduce performance slightly

Strategy 4: Premium/Organic

Template: - Organic corn: 55-60% - Organic soybean meal: 30-35% - Organic wheat: 0-10% - Organic limestone: 1-1.5% - Organic DCP: 1.5-2% - No synthetic amino acids - Organic premix

Advantages: - Premium pricing - Market differentiation - Clean label

Disadvantages: - Higher cost - Limited ingredient options - May sacrifice some performance

Quality Control

Ingredient Testing:

Essential Tests: - Moisture content - Crude protein (NIR or Kjeldahl) - Energy (NIR or calculated) - Mycotoxin screening

Periodic Tests: - Amino acid profile (HPLC) - Mineral analysis (ICP) - Oxidation status (peroxide value, TBARS) - Particle size

Visual Inspection: - Color consistency - Odor (detect rancidity) - Foreign material - Clumping or caking

Finished Feed Testing:

Routine: - Moisture - Crude protein - Crude fat - Crude fiber - Ash - Pellet durability index (PDI)

Periodic: - Amino acids - Minerals (Ca, P specifically) - Vitamin analysis - Mycotoxins

Record Keeping:

- Batch formulation records
- Ingredient lot numbers
- Test results
- Animal performance data
- Cost tracking

Mixing and Feed Manufacturing

Mixing Sequence:

Macro ingredients (45-60 seconds):

- Grains
- Protein meals
- By-products

Micro ingredients premix (separate pre-blend):

- Vitamins
- Trace minerals
- Amino acids
- Additives

Add liquid ingredients last (if using):

- Oil
- Molasses

- Liquid enzymes

4. **Total mixing time**: 3-5 minutes minimum

Mixer Quality:

- **Coefficient of Variation (CV)**: <10% for good mixing
- Test with salt-tracer method
- Verify mixer annually

Pelleting Considerations:

Benefits: - Reduced feed wastage - Improved feed conversion - Reduced segregation - Destroys some pathogens

Pellet Quality Factors: - Die specification (diameter, length) - Conditioning time and temperature - Steam quality - Binder inclusion (bentonite 0.5-1%) - Cooling efficiency

Optimal Pelleting: - Conditioning: 80-85°C, 30-60 seconds - PDI target: >80% for broilers - Crumble size: 2-4 mm for chicks

Cost Management

Price Monitoring:

Track these ingredients closely: - Corn (largest cost component) - Soybean meal (second largest) - Oil prices (volatile) - Synthetic amino acids (steady but significant)

Shadow Prices:

After optimization, calculate shadow prices:

```
Shadow Price = Change in total cost / Unit change in constraint
```

This tells you: - How much it costs to increase a nutrient by 1 unit - Which constraints are most expensive - Where to focus reformulation efforts

Reformulation Triggers:

Reformulate when: - Any major ingredient price changes >5% - New ingredient becomes available locally - Animal performance deviates from expected - New crop harvest (quality changes) - Seasonal adjustments needed

Cost-Saving Strategies:

Use more synthetic amino acids

- Reduce protein level by 1-2%

- Add crystalline AA to meet SID requirements
- Can save 2-5% on feed cost

Optimize phytase usage

- Release 0.10-0.15% available P
- Reduce DCP inclusion
- ROI typically 3:1 to 5:1

Strategic by-product use

- DDGS when corn prices are high
- Wheat bran for pullet/breeder diets
- Local by-products if quality assured

Bulk purchasing

- Forward contracts on major ingredients
- Seasonal buying (harvest time)
- Co-op purchasing with other farms

Multi-phase feeding

- More feeding phases = better nutrient matching
- Reduces over-feeding
- Typical savings: 2-4% on feed cost

Troubleshooting Common Issues

Poor Feed Conversion

Possible Causes: - Energy level too low - Amino acid imbalances - Poor feed quality - Health challenges

Solutions: - Increase energy by 50-100 kcal/kg - Check SID amino acid levels and ratios - Test for mycotoxins - Review biosecurity and vaccination

Leg Problems

Possible Causes: - Ca:P imbalance - Inadequate vitamin D3 - Too-rapid growth - Inadequate trace minerals

Solutions: - Verify Ca 0.9-1.0%, avP 0.45-0.50% in starter - Increase vitamin D3 to 4000 IU/kg - Reduce energy slightly - Check Mn, Zn, Cu levels

Wet Litter

Possible Causes: - Excess protein - High sodium or potassium - Poor water management - Intestinal health issues

Solutions: - Reduce CP by 0.5-1% - Check DEB (target 220-250 mEq/kg) - Add NSP enzymes - Include probiotic/acidifier

Poor Eggshell Quality (Layers)

Possible Causes: - Inadequate calcium - Wrong particle size - Insufficient vitamin D3 - Heat stress

Solutions: - Increase Ca to 4.0-4.3% - Use 50% coarse limestone (2-4 mm) - Ensure vitamin D3 ≥3500 IU/kg - Provide afternoon calcium source

Pale Egg Yolks

Possible Causes: - Low xanthophyll (pigment) intake - Poor absorption

Solutions: - Increase corn gluten meal inclusion - Add xanthophyll supplement - Check fat level (minimum 2%) - Ensure adequate vitamin E

Feed Safety

Mycotoxin Management:

High-Risk Ingredients: - Corn (aflatoxin, fumonisin) - Wheat (DON, zearalenone) - DDGS (concentrated toxins)

Mitigation: - Source from reliable suppliers - Test high-risk ingredients - Use broad-spectrum binders (0.1-0.3%) - Blend multiple ingredient lots

Safe Limits (ppb): - Aflatoxin: <20 ppb - DON: <5000 ppb - Fumonisin: <20,000 ppb - Zearalenone: <500 ppb

Salmonella Control:

- Heat treatment (pelleting >80°C)
- Acidifiers (formic, propionic acid)
- Organic acids in feed
- Proper storage conditions
- Hygiene in feed mill

Storage Recommendations:

Temperature: - Store in cool, dry conditions - Avoid direct sunlight - Maximum 25°C ambient

Moisture: - Keep below 12% moisture - Use moisture barriers - Proper ventilation

Duration: - Starter feeds: <2 weeks - Grower/finisher: <3 weeks - Layer feeds: <4 weeks - Premixes: Use FIFO, <3 months

Oxidation Prevention:

- Add antioxidants (ethoxyquin, BHT/BHA) at recommended levels
- Minimize fat oxidation
- Store oil/fat in dark containers
- Check peroxide values regularly

Environmental Considerations

Nitrogen Excretion:

Reduce environmental impact: - Use SID amino acids (not total) - Add crystalline amino acids - Reduce protein by 1-2% with AA supplementation - Use phytase

Impact: - 1% protein reduction = 8-10% less N excretion - Better amino acid balance = less N waste

Phosphorus Excretion:

- Use available P in formulation

- Include phytase (500-1000 FTU/kg)

- Monitor Ca:P ratio (don’t over-supplement Ca)

Impact: - Phytase can reduce P excretion by 30%

Carbon Footprint:

High-Impact Ingredients: - Soybean meal (land use change) - Animal products (upstream emissions) - Long-distance transport

Lower-Impact Options: - Local grains - Co-products (DDGS, wheat bran) - Synthetic amino acids (efficient production)

Software Tips

Interface Navigation:

- **Dark Mode**: Easier on eyes in low light

- **Light Mode**: Better for printing/presentations

- **Reset Button**: Quick way to start fresh

- **Strain Selector**: Change anytime without losing ingredients

Workflow Optimization:

1. **Save template formulations**: Keep successful formulations as references
2. **Batch processing**: Work on multiple diets in sequence
3. **Price updates**: Update prices weekly before production runs
4. **Seasonal adjustments**: Create summer and winter variants

Data Management:

- Export results regularly
- Document unusual solutions
- Keep ingredient spec sheets updated
- Maintain price history

Learning Features:

- **Experiment with constraints**: See how changes affect cost
- **Compare strains**: Run same diet across different genetics

- **Sensitivity analysis**: Test how price changes affect formulation

Advanced Topics

Multi-Phase Feeding

Concept:

Instead of 3 phases (starter, grower, finisher), use 5-7 phases with gradually declining nutrient density.

Benefits: - Matches bird requirements more precisely - Reduces nutrient excretion - Improves FCR by 2-4% - Lowers feed cost per kg gain

Example - Broiler 6-Phase Program:

Phase	Age (days)	Lysine SID %	AMEn (kcal/kg)
Pre-starter	0-7	1.32	3000
Starter	8-14	1.24	3050
Grower 1	15-21	1.16	3100
Grower 2	22-28	1.08	3150
Finisher 1	29-35	1.00	3200
Finisher 2	36-42	0.94	3250

Implementation:

Use the **Dynamic Model** strain for day-by-day requirements, then create age-band formulations.

Least-Cost vs. Least-Environmental Impact

Traditional Least-Cost:

Objective: Minimize cost

```
Minimize: Σ (Price × Inclusion %)
```

Environmental Formulation:

Objective: Minimize environmental score

```
Minimize: Σ (Environmental Impact Factor × Inclusion %)
```

Where EI factors might include: - Carbon footprint (kg CO2 eq) - Water usage - Land use change - Eutrophication potential

Trade-off: Environmental formulations typically cost 5-15% more than least-cost.

Ideal Protein Concept

Theory:

Formulate based on amino acid ratios relative to lysine, not crude protein.

Lysine = 100, all others expressed as ratio:

Amino Acid	Broiler Ratio	Layer Ratio
Lysine	100	100
Methionine	40	44
Met+Cys	74	82
Threonine	67	67
Tryptophan	16	19
Arginine	105	95
Valine	75	82
Isoleucine	67	72
Leucine	100	109

Application:

1. Set lysine requirement first
2. Calculate all other AA based on ratios
3. Use crystalline AA to achieve ratios

4. Allows protein reduction

Precision Feeding

Individual Bird Feeding:

- Use RFID to identify each bird
- Blend customized diets on-the-fly
- Adjust for sex, weight, growth rate

Benefits: - Reduce feed cost 8-12% - Lower environmental impact - Improve uniformity

Requirements: - Specialized equipment - Sophisticated software - Higher upfront investment

Group Precision:

- Divide house into zones
- Monitor bird weight by zone
- Adjust diet density by zone

Benefits: - Better than whole-house feeding - More practical than individual - Moderate investment

Feed Additives Deep Dive

Enzymes:

Phytase: - Dose: 500-1500 FTU/kg - Releases 0.10-0.15% avP - Can release some Ca, Na, AA - Super-dosing (>1500 FTU) for extra-phosphoric effects

Xylanase: - For wheat-based diets - Breaks down arabinoxylans (NSP) - Improves energy by 50-100 kcal/kg - Reduces viscosity

Protease: - Improves protein digestibility - Can reduce CP by 1-2% - Best in corn-soy diets

Multi-enzyme: - Combination products - May have synergistic effects

Organic Acids:

Types: - Formic acid - Propionic acid - Butyric acid - Citric acid - Lactic acid

Functions: - Lower GIT pH - Antimicrobial effect - Improve nutrient digestibility - Pathogen control

Inclusion: 0.1-0.3% of diet

Essential Oils:

Common: - Thymol - Carvacrol - Cinnamaldehyde - Capsaicin

Functions: - Antimicrobial - Anti-inflammatory - Antioxidant - Flavor enhancement

Inclusion: 50-200 ppm

Probiotics:

Species: - Bacillus subtilis - Lactobacillus spp. - Enterococcus faecium - Saccharomyces cerevisiae

Functions: - Competitive exclusion - Immune modulation - Improved gut health

Inclusion: 10■ to 10■ CFU/g of feed

Matrix Values

Concept:

Account for nutrient contributions from feed additives.

Example - Phytase Matrix:

For 500 FTU/kg phytase: - Available P: +0.10% - Calcium: +0.12% - Sodium: +0.02% - AME: +30 kcal/kg

How to Use: 1. Add the additive to your formulation 2. Reduce nutrient requirements by the matrix values 3. Allows ingredient cost reduction

Popular Matrices:

Additive	Nutrient Released
Phytase (500 FTU)	+0.10% avP, +0.12% Ca
Phytase (1500 FTU)	+0.15% avP, +0.16% Ca, +60 kcal
Xylanase	+80-100 kcal/kg AME
Protease	+1% digestible protein

Caution: Don’t double-count. Be conservative with matrix values.

Future Trends

1. Artificial Intelligence in Formulation

- Machine learning predicts ingredient quality
- AI optimizes across multiple objectives

- Real-time formulation adjustments

2. Near-Infrared (NIR) Spectroscopy

- Instant ingredient analysis
- Quality control in seconds
- Integration with formulation software

3. Blockchain for Traceability

- Track every ingredient lot
- Verify organic/non-GMO claims
- Supply chain transparency

4. Personalized Nutrition

- Genetic testing of flocks
- Microbiome-based feeding
- Real-time health monitoring

5. Alternative Proteins

- Insect meals (black soldier fly)
- Single-cell proteins
- Algae-based ingredients
- Cultured proteins

6. Sustainability Metrics

- Carbon footprint labeling
- Water use efficiency
- Circular economy approaches

Appendices

Appendix A: Nutrient Conversion Factors

Energy:

- 1 kcal = 4.184 kJ
- 1 MJ = 239 kcal
- ME (poultry) ≈ 0.96 × GE (for typical diets)
- AMEn ≈ AME - 8.22 kcal × CP%

Protein:

- N × 6.25 = Crude Protein
- 1 lb protein = 0.454 kg protein
- 1% protein in diet = 10 g/kg or 10,000 mg/kg

Amino Acids:

- SID AA = Total AA × Digestibility coefficient
- Typical digestibility: 75-95% depending on ingredient

Minerals:

- Ca × 1.29 = CaCO■ (limestone equivalent)
- P × 2.06 = P■O■
- Na × 2.54 = NaCl
- K × 1.91 = K■O

Appendix B: Useful Formulas

Energy:

WPSA AMEn Formula (simplified):

```
AMEn (kcal/kg) = 37.13×CP + 81.68×EE + 35.56×NFE - 12.82×CF - 8.22×CP
```

Where: - CP = Crude Protein (%) - EE = Ether Extract (%) - CF = Crude Fiber (%) - NFE = Nitrogen-Free Extract = 100 - CP - EE - CF - Ash

Dietary Electrolyte Balance:

```
DEB (mEq/kg) = (Na% × 434.98) + (K% × 255.74) - (Cl% × 282.06)
```

Energy:Protein Ratio:

```
E:P Ratio = AMEn (kcal/kg) ÷ CP (%)
```

Typical values: - Broiler starter: 130-135 - Broiler finisher: 165-175 - Layer: 170-180

Lysine:Energy Ratio:

```
Lys:E = Lysine SID (%) ÷ AMEn (kcal/kg) × 1000
```

Expressed as g lysine per Mcal ME

Shadow Price (Post-Optimization):

```
Shadow Price = ΔCost ÷ ΔConstraint
```

Tells you the marginal cost of relaxing a binding constraint by one unit.

Feed Conversion Ratio (FCR):

```
FCR = Feed consumed (kg) ÷ Weight gain (kg)
```

Lower is better. Broilers: 1.5-1.8 typical.

European Efficiency Factor (EEF):

```
EEF = (Livability % × Average weight kg) ÷ (Age days × FCR) × 100
```

Composite index of broiler performance.

Appendix C: Recommended Reading

Textbooks:

1. **“Poultry Feedstuffs: Supply, Composition, and Nutritive Value”** by J. McNab & K. Boorman
2. **“Nutrient Requirements of Poultry”** - National Research Council (NRC)
3. **“Feed Formulation”** by C.R. Stark et al.
4. **“Broiler Breeder and Production”** by O. Fasuyi
5. **“Commercial Chicken Meat and Egg Production”** by D.D. Bell

Industry Guides:

- **Ross Broiler Nutrition Specifications** - Aviagen
- **Cobb Broiler Management Guide** - Cobb-Vantress
- **Lohmann Layer Management Guide** - Lohmann Tierzucht
- **Hy-Line Layer Management Guide** - Hy-Line International

Scientific Resources:

- **Poultry Science Journal** (PSA)
- **British Poultry Science**
- **World’s Poultry Science Journal** (WPSA)
- **Journal of Applied Poultry Research** (JAPR)

Online Resources:

- **The Poultry Site** - www.thepoultrysite.com
- **Feedstuffs Magazine** - www.feedstuffs.com
- **AllAboutFeed** - www.allaboutfeed.net

Appendix D: Glossary of Terms

AA (Amino Acid): Building blocks of protein, 20 common in feed

Aflatoxin: Mycotoxin produced by Aspergillus fungi, toxic to poultry

AME (Apparent Metabolizable Energy): Gross energy minus fecal and urinary energy

AMEn: AME corrected for nitrogen retention

ANF (Anti-Nutritional Factor): Compound that reduces nutrient utilization

avP (Available Phosphorus): Non-phytate phosphorus, readily absorbed

BCAA (Branched-Chain Amino Acids): Valine, leucine, isoleucine

Binding Constraint: A constraint that limits the optimum solution

CFU (Colony Forming Units): Measure of viable microorganisms (probiotics)

CP (Crude Protein): Total nitrogen × 6.25

DDGS (Dried Distillers Grains with Solubles): Ethanol by-product

DEB (Dietary Electrolyte Balance): Na + K - Cl in milliequivalents

DM (Dry Matter): Feed excluding water content

EE (Ether Extract): Crude fat content

Feasible Solution: A diet formulation that meets all constraints

FCR (Feed Conversion Ratio): Feed intake ÷ weight gain

FTU (Phytase Units): Enzyme activity measurement

GE (Gross Energy): Total energy in feed by bomb calorimetry

IU (International Units): Measurement for vitamins A, D, E

Linear Programming: Mathematical optimization method

ME (Metabolizable Energy): Energy available after fecal/urinary losses

Mycotoxin: Toxic compound produced by fungi

NFE (Nitrogen-Free Extract): Carbohydrates = 100 - CP - EE - CF - Ash

NIR (Near-Infrared Spectroscopy): Rapid feed analysis method

NSP (Non-Starch Polysaccharides): Complex carbohydrates, often anti-nutritive

PDI (Pellet Durability Index): Measure of pellet quality

ppb (parts per billion): 1 ppb = 1 µg/kg

ppm (parts per million): 1 ppm = 1 mg/kg

Shadow Price: Marginal value of relaxing a constraint

SID (Standardized Ileal Digestible): True ileal digestibility corrected for endogenous losses

Simplex Algorithm: Linear programming solution method

WPSA (World’s Poultry Science Association): International poultry science organization

Appendix E: Contact & Support

Software Version:

Feed Formulation Pro v2.1 Build: 77 ingredients Developer: PHD Khaleghi Feed Formulation Research

Updates:

Check for software updates and new ingredient databases regularly to ensure you have the latest nutritional data and features.

Feedback:

Your feedback helps improve Feed Formulation Pro. Please document: - Feature requests - Bug reports - Ingredient database updates - Usability suggestions

Training:

For questions on nutrition or formulation strategy, consult: - University extension services - Nutrition consultants - Genetic company technical services - Feed company nutritionists

Disclaimer:

This software is intended as a tool for professional nutritionists. Always verify formulations with: - Feeding trials - Laboratory analysis - Expert consultation - Regulatory compliance

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Thank You

Thank you for using **Feed Formulation Pro - PHD Khaleghi**. We hope this comprehensive guide helps you formulate optimal, cost-effective diets that meet your production goals while maintaining animal health and welfare.

Good luck with your formulations!