Food and Agriculture Organization of the United Nations

Feed processing technology – an international perspective

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FAO, Rome, Italy

Outline

1. Feed Technology – Historical Perspectives and Recent Developments

2. Feed Safety and Quality – Good Practices

3. Where to from here ?

Feed technology in the last five decades

Feed Technology – fueled by increasing demands

Dictated by:

making equipment easier to handle, more efficient, use of novel feed ingredients

Feed technology -- a historical perspective

1960-1980: Modernization Period

Use of roller mills, hammer mills and pellet pressings

Storage of pelleted feeds with delivery to farmers on request

Feed formation in view of legislations

Limited automation

Publications on feed technology – process conditions affect quality of pelleted feeds – performance and nutrient digestibility

1980-2000: Consciousness Period

Mycotoxins and anti-nutritional factors recognized

Technologies to minimize their effects (toasting and radiation) & pelleting

Environment & animal welfare

Use of feed additives [stability and mixing to concerns e.g. antibiotics]

Development of good quality systems & process optimization

1983- First symposium on particle size reduction – Kansas University

(decrease in cost: energy cost reduction, increase in feed efficiency, optimization of pelleting and conveying; animal species and their physiological stage consideration)

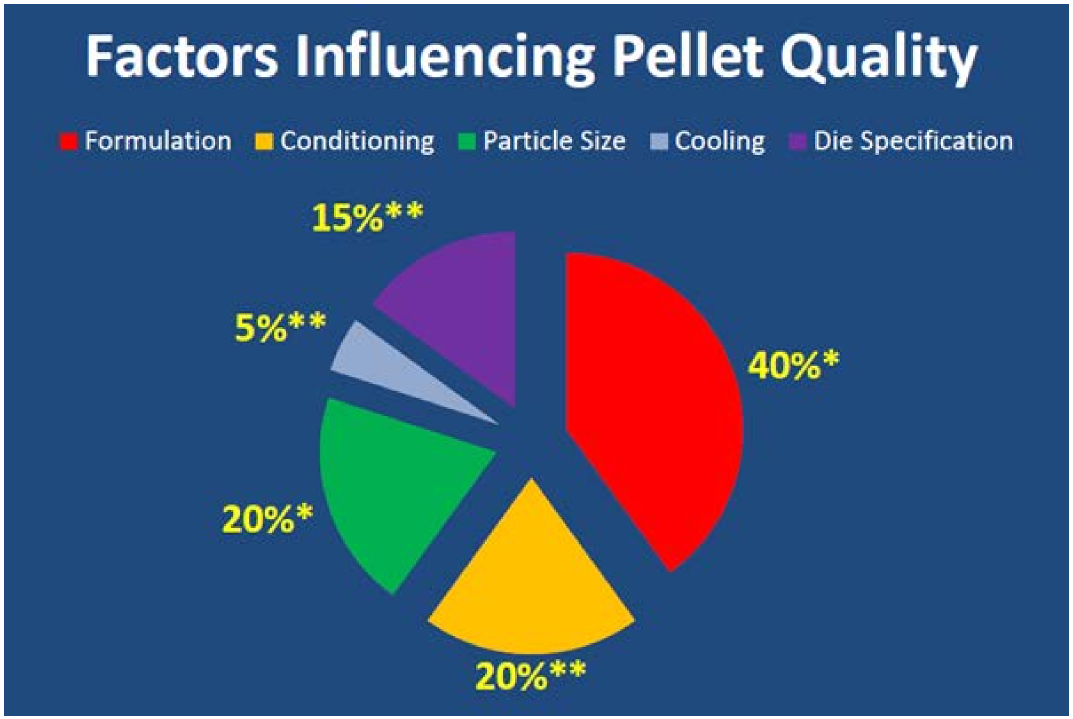
Feed technology -- a historical perspective

2000-2020: Tailored feed production

- Customer-oriented compound feed production
- Feed safety and quality, animal health, hygiene
- Feed additives – benefits and concerns antibiotics)
- Reduction in costs, target nutrient delivery, synthetic amino acids use
- Liquid feed delivery
- Processing integral part of nutrient utilization
- Better control of plants : mixing, grinding, conditioning (proper process and over-processing), pelleting
- On-line NIRS integration
- Analytical methods to test processed animal proteins

Mantra-- Physical quality is important but it should not be at the expense of nutritional quality

Factors controlling pellet quality



Quality – a combination of factors:

- **Durability (+++): transport & handling**
- **Hardness* and appearance including colour**
- **Surface texture**
- **Uniformity of size**
- **Percent fines**
- **Palatability**

* Weight without breaking (hardness & durability not always correlated

- Finer the particles better quality
- State of the equipment: hammer, die, knife, rollers incorrect position of blades, steam valves

Feed technology -- recent developments

Particle size control

A good grinder?

Even-size particles – better control over particle size
Energy efficiency
Flexibility in using different raw materials

Roller and hammer mills together preferred
However height of plant becomes an issue

New hammer mills:
large rotor
low speed
8 screens

120 tons/h (800 kW)
20-40 tons/h (355 kW)

A high capacity hammer mill

Feed technology -- recent developments

Liquids in feed mill

Earlier

- Liquid raw materials were just ‘topping’, applied at 1-2 %
- Dosing from storage tank, above mixers (storage of liquid at temp > Melt. point)
- Using volumetric counter flow devices
- Large amount of dust sticking to walls and inside ribbon of mixer
- Hygiene not a big issue

Now

- Continuous mixer below the main mixer
- Liquids sprayed in the continuous mixer, as the mixer passes through
- No lump formation though frequent cleaning required
- Next step is in the conditioners


Continuous mixer with 2 addition lines

Feed technology -- recent developments

Mixing: an important step

Efficient mixing being key to good feed production

Optimum mixing: ensures uniform distribution of nutrients, vitamins and minerals

↓

A homogeneous nutrient content in each feed pellet.

↓

Ensure optimum growth of the animals.

What is a good mixer

Provides both fast and efficient mixing

Easy to clean (no cross contamination, from one formula to another)

All ingredient in every pellet

Conditioning & Pelleting

Feed processing
- Grinding
- Mixing
- conditioning
- Pelleting
- Dehydration
- Cooling

Before mesh enters the pelleting stage
- Conditioning step – vital
- Steam supply system-- critical

Steam generation, control & quality

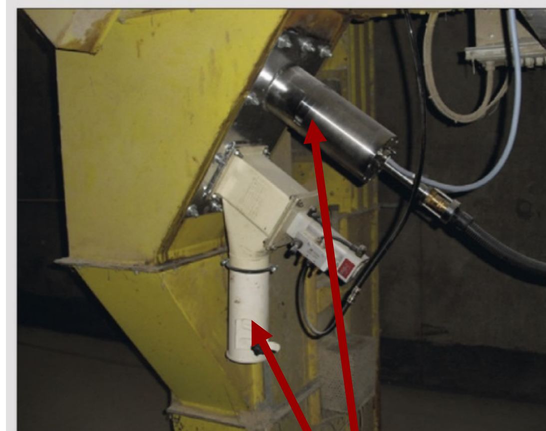


Figure 1. On-line NIR probe and sampling device installed at a feed reception stage (courtesy of Provimi, France. Q-Saffe European project).

Dry pelleting
- More starch damage
- Though low energy cost

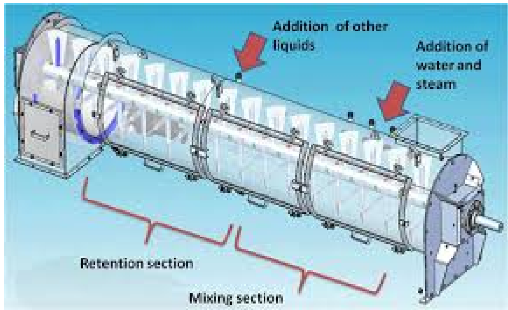
Steam-conditioned pelleting
- Improved pellet quality
- Higher productivity
- Though higher energy cost

Online quality Control using NIRS

Pellet quality is established in conditioner rather than in pellet die

Feed technology -- recent developments

Conditioning and pelleting



Advantage of pelleting

- Reduce pathogens
- Increase density of feed, and absorption of nutrients (+)
- reduce segregation of ingredients during transport and feeding

Conditioners before pelleting

- short term conditioning: steam conditions 20 – 30 sec
- long term conditioning: steam for > 60 sec
- Conditioning for 5 to 8 min at a temp

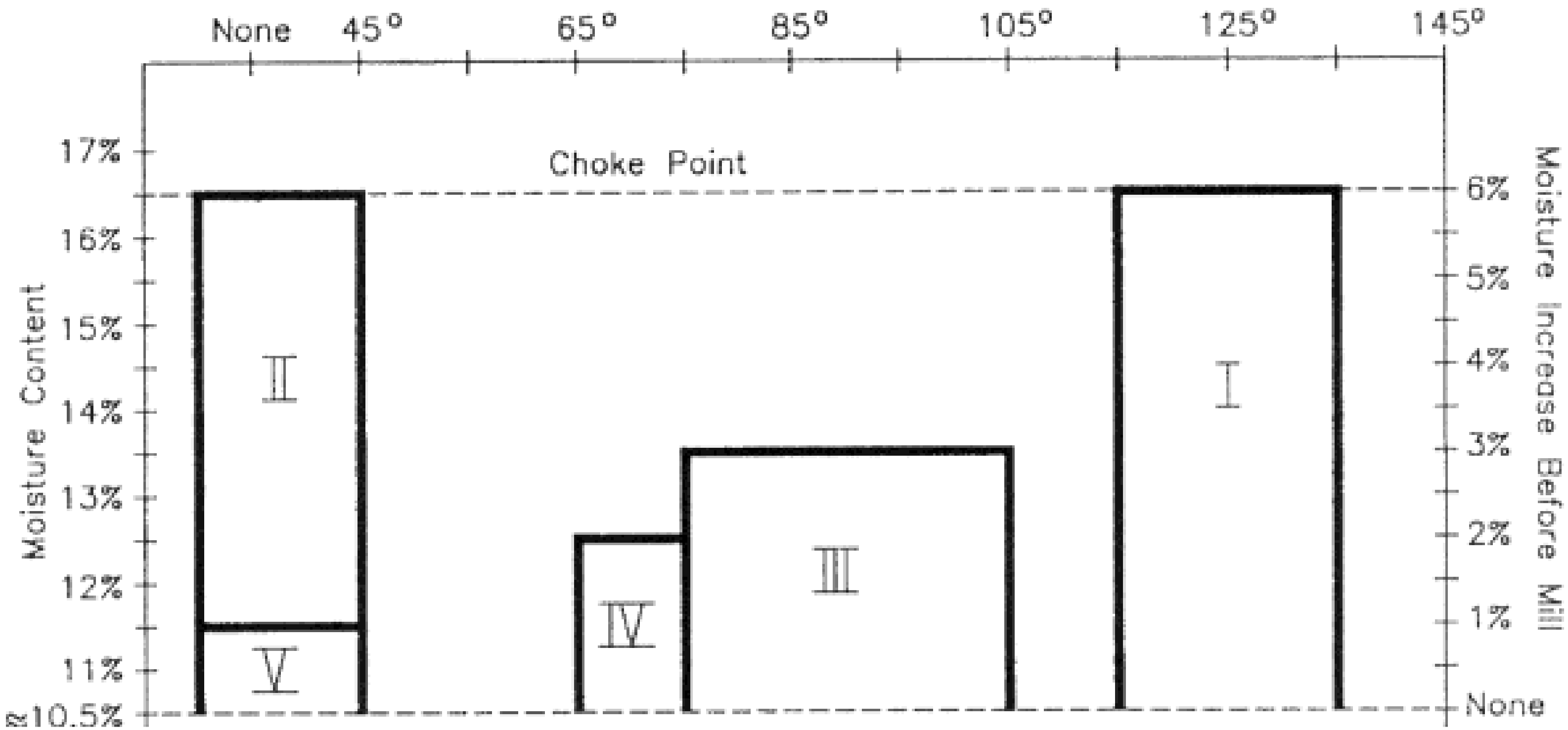
Conditioning

- Starch gelanisation (optimum 70 C and 25% moisture; time not much effect)
- Nutrient utilization (++)
- Pathogen mitigation, reduction/elimination in antinutrients
- Starch gelanisation is maximum from physical process: pressing through die

Thermal processing: increased daily gain and feed efficiency

Conditioning temperature and moisture requirement

Feed categories (I = high starch; II = heat sensitive high starch; III = high natural protein; IV = high fiber; V = high urea/molasses)



Optimum: 16-16.5% moisture

Steam system, control and quality

Steam system: poorly understood and badly managed

Steam properties:

Saturated steam temperatures for a range of operating pressures typically found in steam systems in feed mills

Gauge Pressure	Absolute Pressure	Steam temp
psig	psia	°C
0	14.7	100.0
20.3	35.0	126.3
30.3	45.0	134.7
40.3	55.0	141.7
50.3	65.0	147.8
60.3	75.0	153.1
70.3	85.0	157.9
80.3	95.0	162.3

Steam quality

- % of steam in water phase
- Steam passes through pipes, steam cools and turns into a mix of dry and liquid vapour (wet steam) – low energy if enters into conditioner
- More wet stream – lower increase in temp but higher increase in moisture – plugging of machine or low pellet quality

Steam supply

- Steam boiler
- Steam piping
- Steam regulation

Good practices

Steam moisture-temperature optimization

Temp IN

20 degree C

Conditioner

Temp OUT

70 degree C

Steam

Real time Moisture - Online humidity technology

New vs old crop Moisture?

For every 14 degree C increase 1% moisture added

Moisture increase = 5% points

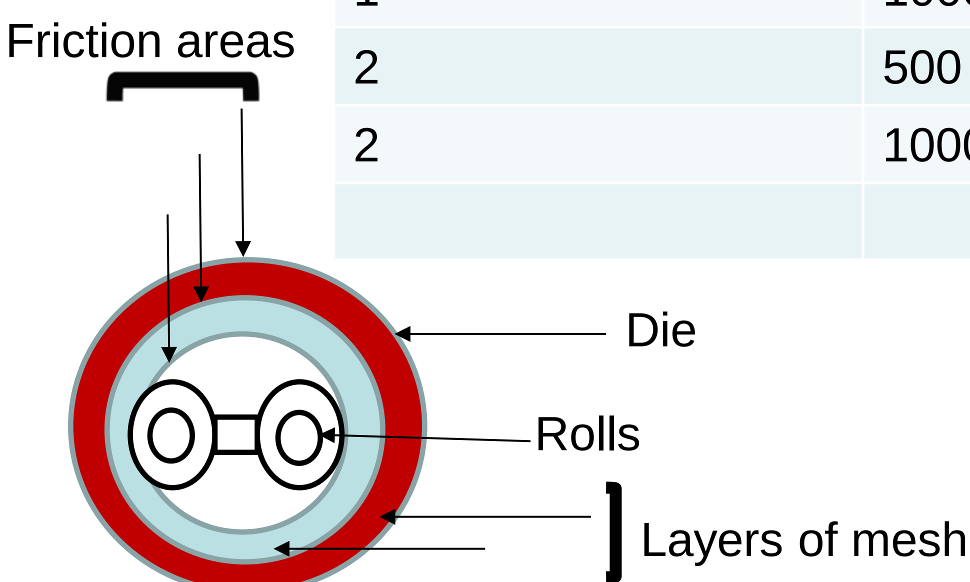
Too much moisture (due to excess steam) to feed mesh	Rolls of pellet machine slip on the die surface
Too little moisture	Dry and brittle pellets
Too much heat	Denaturation of nutrients and low feed efficiency
Too little heat	Frictional heating in die, shorten die life, Reduction in pellet mill capacity

Optimizing press settings

Effect of roller-die gap and feeder rate on pellet durability index (PDI)

Distance between Roller and die (mm)	Feeder rate (kg)	PDI (%)
0.1	500	85.6
0.1	1000	82.8
1	500	87.7
1	1000	85.8
2	500	90.6
2	1000	85.6

Higher energy use
Lower production capacity



Other factors:

- Die hole and die dia
- Die thickness & feeder rate

Dustiness and fire hazards

If you google: "feed mill" and "fire“

Over 100,000 results.

Suggests that a feed mill is a definite fire hazard. In most cases, dust is the accelerating cause for mills to completely burn down or in the worst case to explode. Enough reason to pay attention to explosion prevention.

In the US 281 combustible dust incidents between 1980 and 2005 --
-- killed 119 workers
-- injured 718, and extensively
-- damaged industrial facilities.
-- Injuries or fatalities occurred in 71% of the incidents."

Improper storage – smoking/fire

Reasons: high moisture, compact ness, less aeration

Prevention: moisture < 13%, in sacs (not too high) & sufficient space between rows

First in, first out approach

Proper transport as well

Smoked

Feed materials with high moisture content undergo physical and biochemical changes when stored at high temperature and high relative humidity.

Especially grains: bursting and gelatinization of starch, increase in feed sugar, production of alcohol and acetic acid, resulting in a sour odour.

Knife setting and pellet quality

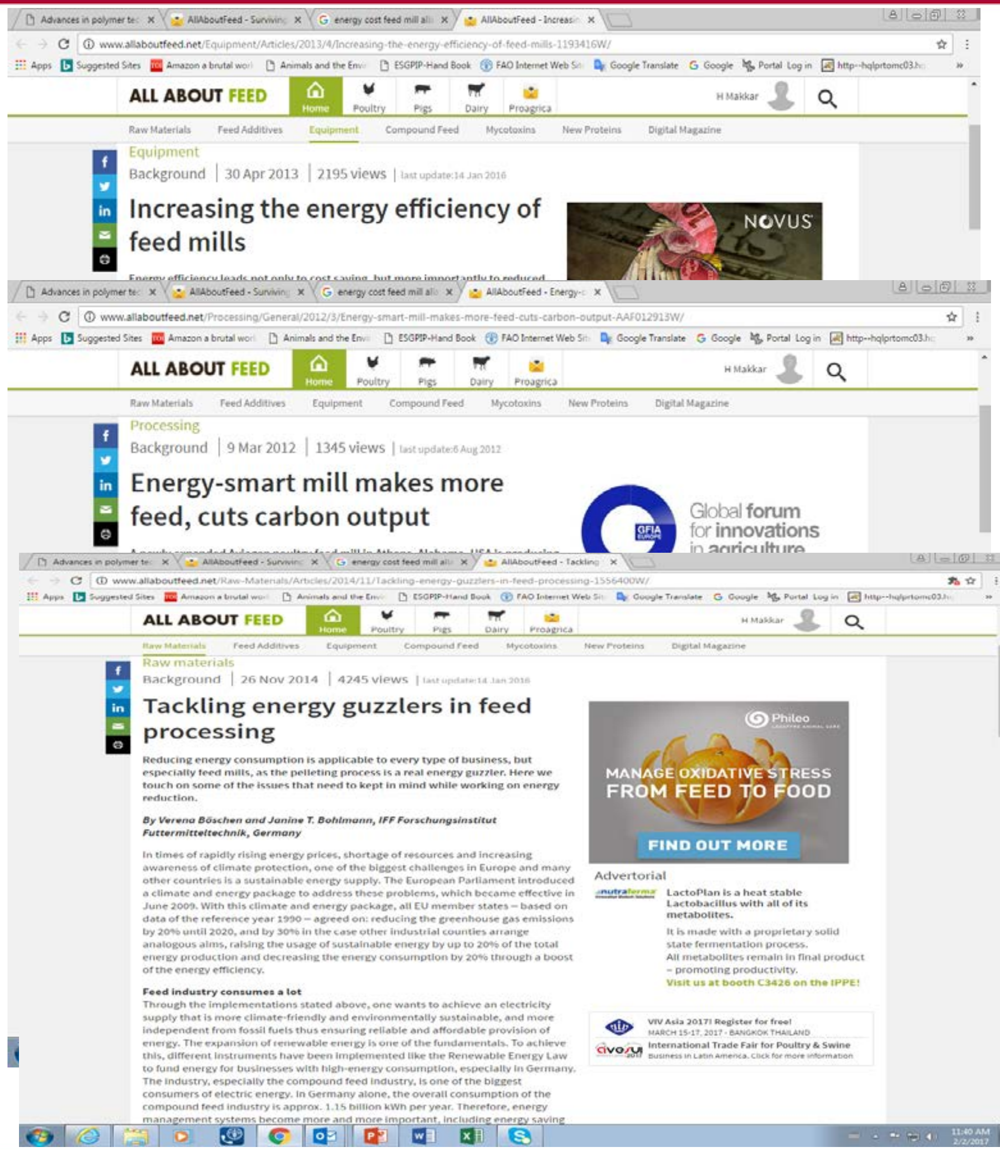
Cutter at outside of pellet press

The research showed that the condition of knives (worn or sharp)

affect the physical quality of feed pellets.

Worn knife : More dustiness

Reduction in Energy Cost



ALL ABOUT FEED

Equipment

Background | 30 Apr 2013 | 2195 views | last update:14 Jan 2016

Increasing the energy efficiency of feed mills

Processing

Background | 9 Mar 2012 | 1345 views | last update:6 Aug 2012

Energy-smart mill makes more feed, cuts carbon output

Raw materials

Background | 26 Nov 2014 | 4245 views | last update:14 Jan 2016

Tackling energy guzzlers in feed processing

Reducing energy consumption is applicable to every type of business, but especially feed mills, as the pelleting process is a real energy guzzler. Here we touch on some of the issues that need to kept in mind while working on energy reduction.

By Verena Böschen and Janine T. Bohlmann, IFF Forschungsinstitut Futtermitteltechnik, Germany

In times of rapidly rising energy prices, shortage of resources and increasing awareness of climate protection, one of the biggest challenges in Europe and many other countries is a sustainable energy supply. The European Parliament introduced a climate and energy package to address these problems, which became effective in June 2009. With this climate and energy package, all EU member states – based on data of the reference year 1990 – agreed on: reducing the greenhouse gas emissions by 20% until 2020, and by 30% in the case other industrial counties arrange analogous aims, raising the usage of sustainable energy by up to 20% of the total energy production and decreasing the energy consumption by 20% through a boost of the energy efficiency.

Feed industry consumes a lot

Through the implementations stated above, one wants to achieve an electricity supply that is more climate-friendly and environmentally sustainable, and more independent from fossil fuels thus ensuring reliable and affordable provision of energy. The expansion of renewable energy is one of the fundamentals. To achieve this, different instruments have been implemented like the Renewable Energy Law to fund energy for businesses with high-energy consumption, especially in Germany. The industry, especially the compound feed industry, is one of the biggest consumers of electric energy. In Germany alone, the overall consumption of the compound feed industry is approx. 1.15 billion kWh per year. Therefore, energy management systems become more and more important, including energy saving

Advertorial

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Economics of feed drying

-- Energy required to change liquid water into vapour (latent heat of vaporisation) is about 2,350 kJ/kg of water evaporated

-- Typically, dryers will use between 3,000 kJ/kg and 4,500 kJ/kg of water evaporated. A very poorly-operated or poorly-designed dryer might even use much more.

-- Based on a typical value of 3,250 kJ/kg of water evaporated, an extruded feed line producing 75,000 tons per year will typically use about 5 x 10^{10} kJ/year.

Cost will change:

- Natural gas
- Electricity
- Solar power

Economics of feed drying

Drying operation has a significant impact on the bottom line

- You may be sending over 3% of your production out the exhaust stack without even knowing it.
- Downtime for dryer cleaning and maintenance may also be costing you more than you know.

	Inlet moisture	Outlet moisture	Water removal per ton of product produced	% Increase in water removal
1	24%	10%	184 kg	-
2	27%	10%	233 kg	27%
3	30%	10%	286 kg	55%
4	30%	7%	329 kg	79%

Economics of feed drying

Moisture uniformity

Most extruded feeds are sold by weight. If the product is over-dried, it mean sending water at the value of your product

Suppose that your feed cannot contain over 10% moisture limit
Product coming out of your dryer has a moisture variation of ± 3% moisture on a wet-weight basis.

This means you must dry your product to 7% moisture on average in order to ensure that no product is over the specified 10% moisture limit.

The result is a 3% loss in production compared to drying the product only to 10% moisture. If dryer could be made to dry more uniformly, you could raise your discharge moisture and get more out of the production line with no additional cost or additional dry ingredients.

Production 75,000 tons per year. A 3% lost in production from this line represents 2,250 tons per year of lost production. At US$400 per ton, it is US$900,000. At US$600 per ton, it is US$1.35 million

A well-designed, well-adjusted feed dryer should be able to dry feed to within ±0.75% or better. When was the last time you checked the moisture uniformity on your dryer?

Economics of feed drying

Maintenance and sanitation

Many extruded feed producers struggle to keep old, high-maintenance equipment running. The cost of purchasing replacement parts for the dryer may be well documented, but what about the cost of downtime for cleaning and maintaining the equipment?

A dryer producing 10 tons per hour of extruded feed can be producing well over US $100,000 worth of product each day.

If you are spending even three hours a week of unplanned maintenance or cleaning downtime, you have lost 30 tons of final product per week, which equates to US $650,000 per year of lost production.
The cost of this downtime must be considered when looking at the economics of your drying operation.

- Please look at your drying operation
- Infact look at energy cost at every step, identify hotspots and put in place interventions

Feed Safety and Quality – Good Practices

Animal feed, animal health and human wellbeing nexus

- Unsafe feed leads to poor animal health and welfare, which impacts adversely human health and wellbeing
- Quality of animal feed affects the quality of animal-sourced food, which in turn affects human health.

Outbreaks of BSE and diseases due to *Salmonella, E. coli O157, Listeria* etc. forced feed industry and Governments to develop stringent quality & safety control systems

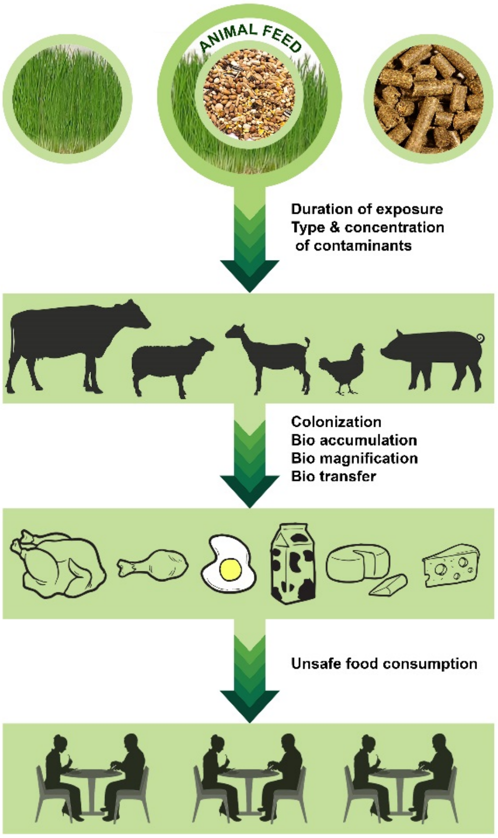
Melamine in feeds from Vietnam
---Thai authorities, Nov 2016

Mycotoxin prevalence increasing in Asia
--- Biomine survey, 2016

Aflatoxins are of concern in distiller grains
--- Makkar (2013)

Health Hazards associated with animal feed

SOURCES OF CONTAMINATION IN ANIMAL FEED



SAFE ANIMAL FEED - SAFE FOOD - SAFEGUARD HUMAN HEALTH

Role of business operators/primary producers

Major responsibility in producing safe feed lies with the manufactures of animal feed including manufactures of feed additives, medicated feed

.

Both equally important

The role of primary producers and other allied operators such as suppliers, distributors, storage providers etc are equally important in ensuring feed safety

Basis for feed safety systems

Many countries have made

- Good Manufacturing Practices (GMP) and
- Hazard Analysis and Critical Control Point (HACCP)

based feed safety system mandatory for:

- Preparation
- Storage and
- Transportation of animal feed

(starting from the primary production)

Good Hygiene Practices (GHP)
Good Agricultural Practices (GAP)

Integration

ROLE OF PRIMARY PRODUCERS AND ALLIED OPERATORS

- ✓ **Implement Good Hygiene Practices (GHP) to avoid the microbial and other contaminations of the product.**

- ✓ **Implement Good Agricultural Practices (GAP) to ensure that the product is not contaminated from environmental contaminants such as heavy metals, pesticides etc.**

- ✓ **GAP include selection of suitable farm lands, selection of good quality seeds and propagation materials, crop rotation and soil management, feed management, pest management, water quality management, waste management, animal health management, harvesting, storage & transportation, input and output management, record keeping etc.**

- ✓ **Conduct regular monitoring of agricultural fields/animal farms to ensure the health and welfare of cultivated plants/ reared animals involved in the production of animal feed. Have an effective animal/ plant health programme in place.**

ROLE OF PRIMARY PRODUCERS AND ALLIED OPERATORS

- ✓ Adopt temperature controls and moisture controls to avoid contamination of products from microbes and also from bio toxins.
- ✓ Proper pest control system shall be adopted to avoid product contamination. Prevent introduction and spread of contagious diseases and report such disease outbreaks to the Competent Authority at the earliest.
- ✓ Establish traceability system to trace back the inputs and outputs.
- ✓ Care shall be taken for the use of pesticides, veterinary drugs and other toxic chemicals to avoid residual contamination. Proper storage and use of chemicals shall done with record keeping.
- ✓ Primary producers and allied operators shall take necessary registration/ permission from the Competent Authority, as applicable, after complying all the legal requirements specified by Competent Authority

ROLE OF FEED MANUFACTURERS

A. **LAYOUT AND CONSTRUCTION**

B. **FEED SAFETY CONTROL SYSTEM**

I. **HACCP**:- The principles of Hazard Analysis and Critical Control Point (HACCP) developed by 'Codex Committee on Food Hygiene' provide the systematic basis for the identification and control of hazards so as to ensure the safety of feed.

II. **Hygiene & Sanitation**:- Good Hygienic Practices (GHP) at all stages of production, processing, transportation, storage and distribution are one of the most important component of Feed Safety Management System which will help to avoid contamination of the product from environment, food contact surfaces, water, employees and other possible sources.

III. **Personal Hygiene:-** Since employees are the major source of contamination, business operators are to develop proper control measures to ensure employee's personal hygiene, appropriate movements and behaviour.

ROLE OF FEED MANUFACTURERS

Good Manufacturing Practice (GMP):- **GMPs are practices and procedures adopted to ensure the safety and suitability of feed and food that can be applied throughout the feed/ food chain**.

- **Incoming materials**
- **End product specification**
- **Process control**
- **Incorporation of feed additives and pre-mixtures:**
- **Control of carry-over**
- **Control of undesirable substances**
- **Quality Control**
- **Storage management**
- **Control on cross contamination**
- **Waste Management**

✓ **Traceability and recall procedures**
✓ **Packing**
✓ **Labelling**

ROLE OF FEED MANUFACTURERS

Dealing with non-conforming products:

- **Business operator must evaluate the cause of the non-compliance and conduct risk assessment for the procedure proposed to be used for dealing with the affected product.**

- **The affected batch must be segregated immediately by a responsible person to avoid cross contamination.**

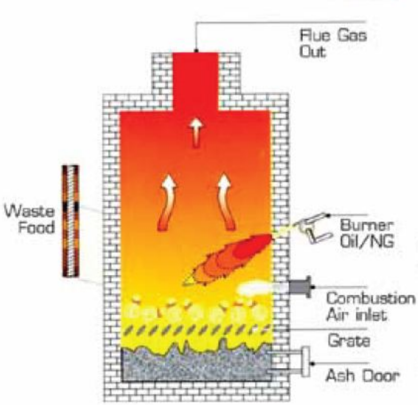
- **Non-conforming products shall be reworked, downgraded or disposed by the business operator, after obtaining clearance from the Competent Authority.**

ROLE OF FEED MANUFACTURERS

Dealing with non-conforming products:

✓ Depending upon the type of contamination/defect, following methods of disposal may be adopted.

- Burying the product without polluting the environment.
- Sterilising the product under pressure and then bury in a suitable place.
- Incinerating or co-incinerating the product with or without sterilising.
- Making the product into organic fertilisers/soil improvers after processing.
- Composting or anaerobic digestion after processing/pressure sterilisation.
- Using the product as fuel for combustion.



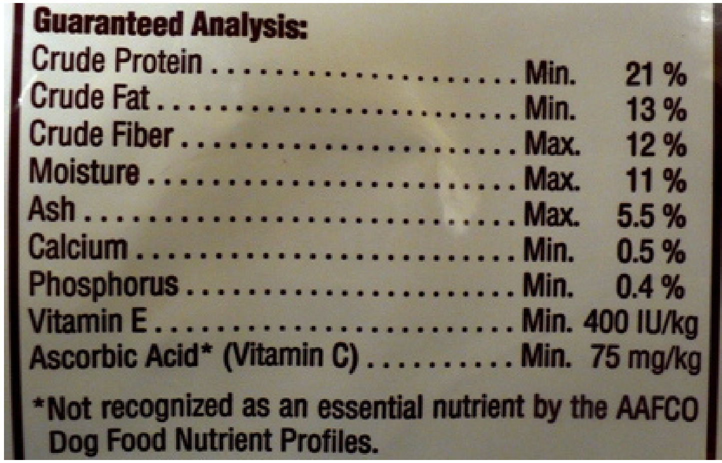
Incinerator

✓ The procedure will be executed under the supervision of the Competent Authority. The Authority may charge a fee for its services.

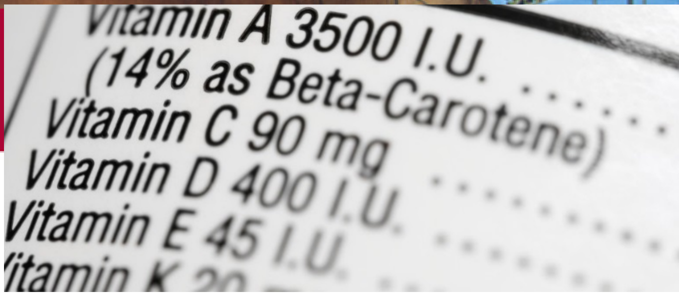
Labelling of feeds

General Requirements for Labeling

i. Name, address & contact number of the producer/ manufacturer of the feed, including approval number, as applicable .
ii. Country of origin (in case of international trade).
iii. Type of feed (e.g.: feed materials, complimentary feed or, complete feed etc).
iv. Lot identification number.
v. Net quantity (in units of mass or volume).
vi. Moisture content of the feed



Labelling of feeds



Special Labeling Requirements for compound feed

a. Information about the species or category of animals for which the feed is intended.
b. Manufacturing and expiry dates.
c. Instructions for the proper use of feed, highlighting the purpose for which the feed is intended for.
d. Analytical constituents of compound feed such as crude protein, crude fat, crude fiber, lysine, calcium etc with percentage of composition shall be labeled.
e. List of Feed materials contained in the feed in descending order by weight.
f. Feed additives having maximum permissible limit and 'Zootechnical additives, coccidiostats and histomonostats', etc shall be mentioned in the label.

Strict norms and control systems for quality & safety

- Implementation of Good Hygiene Practices (GHP), Good Agricultural Practices (GAP), Good Manufacturing Practices (GMP) and HACCP, starting from primary production, is of utmost importance in establishing feed safety.

- Feed safety can be established only through the collective efforts of all the stake holders of the food chain and the governmental agencies.

- Both the business operator and Competent Authority shall play a pivotal role in ensuring the high level protection of human health and animal welfare through feed safety.

- Competent Authority shall establish regular monitoring, sampling and testing to ensure that the feed safety system is in place and the feed produced is safe for the targeted animal.

Strict norms and control systems for quality & safety

- **Proper authorisation of the animal feeds and also the premises of its manufacture shall be given by the Competent Authority, after conducting satisfactory audits.**

- **Only authorised/certified feeds, feed additives and medicated feeds shall be allowed for national or international trade.**

- **The establishments meant for manufacturing animal feed, feed additives, medicated feeds shall be approved and monitored by the officials of Competent Authority.**

- **Well equipped laboratories shall be established by the Competent Authority for testing all the quality and safety parameters of the feed as per the international requirements.**

Need for a strong feed regulatory authority

Regulatory authority (quality and safety aspects):

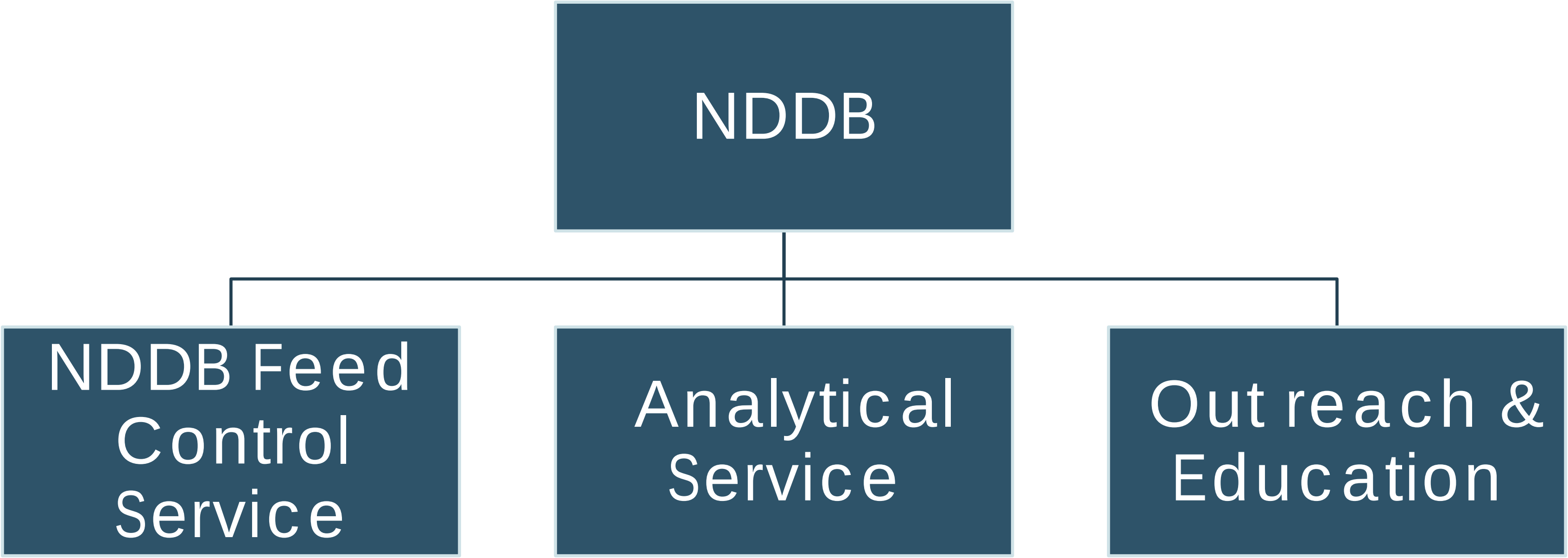
- Test commercial feed ingredients for the industry to establish a baseline
- Conducting risk assessment and guide the feed industry

Where to from here ?

Feed Regulatory Authority

Will take time

Why not have



What intervention/changes ?

“If we do not know what we have or where we are, it becomes impossible to put in place interventions to make improvements”

Stage 1

- **Situation analysis**
- **Base line determination**

For example:

- **Energy cost determination at each important stage**
- **Feed or feed ingredient wastage determination at each state**
- **State and functioning of grinding, conditioning, pelleting, drying stages?**
- **GMP/GHP/GAP: what these are? Are we following them?**
- **An analysis of HCCAP**

Check list?

Stage 2

- **Identification of interventions to improve the situation (for each of the modules).**

Stage 3

- **Development of tools and mechanisms to monitor the situation at regular intervals**

Change has never happened this fast before, and will never be this slow again

Thanks for your attention