Department of Animal Nutrition, Genetics & Breeding
Course Title: Poultry Nutrition
Course Code: ANGB 356
Level-3, Semester-II
Credit Hours: 1, Contact Hour: 2

Course Content (Practical)

1. Identification of poultry feed ingredients
2. Study on feed mill operation practices
3. Study on Blending/ Dosing of feed ingredients
4. Study on Grinding of feed ingredients
5. Study on Mixing of feed ingredients
6. Study on Pelleting of feed ingredients
7. Study on Delivery of finished products
8. Formulation of Poultry Ration by Step Method
9. Field trip commercial poultry farm and mills in Bangladesh
10. Survey of feed market

Experiment 01
Identification of Poultry feed ingredients

Raw materials for feed or feed ingredients are the building stones of a compound feed.
Before attempting to formulate a balanced, compound feed for poultry or pigs we need to pay attention to the ingredients.
The following will be dealt with:

- Identify and recognize the different ingredients.
- Use your eyes, your nose, and your touch. Do not taste!
- Know their origin: what product are they or from what processes are they the (by) product?
- Look for their strong and weak properties, the effect they have on the feed, the animal, and its performance.
- To what extent can we use them in the different feeds? (Inclusion rates)

Chemical Composition of Poultry Feed Ingredients

Cereals & Seeds	**ME (Poultry) kal/kg**	**D.E. Kcal/kg**	**C.P. %**	**D.C.P. %**	**Iys %**	**m+c %**	**mety %**	**fat %**	**fibre %**	**Ca %**	**P %**	**moisture %**
Maize	3340	3593	8.7	6.6	0.22	0.35	0.20	3.6	2.1	0.04	0.30	13.1
Sorghum	3260	3665	10.0	7.8	0.23	0.35	0.16	3.1	2.1	0.03	0.30	12.6
Millet	2930	2994	11.1	8.2	0.20	0.50	0.30	3.2	8.9	0.03	0.32	12.7
Barley	2790	3274	10.6	8.5	0.38	0.42	0.20	2.4	4.5	0.07	0.36	13.6
Wheat	2980	3441	12.1	10.3	0.35	0.48	0.18	1.8	2.2	0.07	0.35	13.9
Beans (Phaseolus). toasted	2520	2974	23.0	17.0	1.52	0.53	0.28	1.6	4.3	0.16	0.46	13.5
Peas	2490	3300	20.7	18.2	1.49	0.50	0.23	1.3	5.5	0.09	0.38	13.1
soybeans, toasted	3310	4241	35.5	31.6	2.27	1.03	0.51	18.8	5.8	0.23	0.52	11.5
Linseed		4657	21.6	16.8	0.80	0.84	0.43	34.3	8.1	0.28	0.62	9.3
rapeseed	4520	4852	20.6	17.1	1.19	0.97	0.43	41.7	9.7	0.48	0.76	7.2
sunflower seed (decort)	5500	6459	27.7	24.4	0.94	1.08	0.42	44.7	3.6	0.18	0.74	6.6
Cereal By-Products												
maize gluten feed	1900	2291	19.4	13.6	0.58	0.72	0.34	2.6	7.9	0.04	0.87	11.8
maize bran (37% starch)	2520	3247	12.0	8.8	0.49	0.49	0.23	5.8	6.0	0.10	0.50	11.0
maize bran (50% starch)	2740	3385	8.7	5.8	0.36	0.36	0.17	6.3	5.2	0.10	0.50	12.5
wheat middling	1980	2301	15.6	10.3	0.62	0.59	0.25	3.6	9.2	0.11	1.15	14.0
wheat bran	1710	2094	15.2	9.3	0.61	0.58	0.25	3.5	10.7	0.19	1.27	13.4
rice bran 9-15% fibre	2200	2934	13.3	9.0	0.63	0.53	0.27	10.2	11.9	0.10	1.58	10.8
Oil meals												
Soybean meal	2120	2900	43.0	39.6	2.75	1.33	0.65	1.8	6.5	0.30	0.65	13.4

Cereals & Seeds	ME (Poultry) kal/kg	D.E. Kcal/kg	C.P. %	D.C.P. %	Iys %	m+c %	mety %	fat %	fibre %	Ca %	P %	moisture %
sesame-expeller/cake	2480	3337	44.3	39.9	1.11	2.17	1.24	10.4	6.3	1.68	0.94	6.7
Groundnut meal (solv. extr.)	1940	2584	50.3	44.8	1.66	1.21	0.55	0.5	12.5	0.18	0.63	10.0
groundnut-expeller/cake	2580	3238	39.1	35.6	1.29	0.94	0.43	7.5	10.0	0.18	0.57	8.1
Cottonseed meal (solv. extr.)	1510	2043	36.6	27.5	1.39	1.21	0.59	2.2	16.7	0.20	1.03	10.1
Cottonseed-expeller/cake	1840	2422	37.1	27.8	1.41	1.22	0.59	6.9	16.8	0.24	1.09	8.0
Coconut meal (solv. extr.)	1340	2513	21.3	13.4	0.49	0.62	0.30	2.4	14.1	0.13	0.58	9.9
coconut-expeller/cake	1850	3719	20.0	13.4	0.46	0.58	0.29	12.2	13.4	0.11	0.44	7.2
Linseed meal (solv. extr.)	1400	2697	32.2	25.1	1.19	1.26	0.64	3.1	10.2	0.37	0.86	9.9
Rape seed meal (solv. extr.)	1730	2349	34.0	25.2	1.70	1.56	0.73	2.3	11.0	0.71	1.09	12.1
Sunflower seed meal (solv. extr.)	1370	1894	28.5	22.5	0.97	1.11	0.63	2.0	24.5	0.33	1.08	11.7
Animal Proteins	**ME (Poultry) kal/kg**	**D.E. Kcal/kg**	**C.P. %**	**D.C.P. %**	**Iys %**	**m+c %**	**mety %**	**fat %**	**fibre %**	**Ca %**	**P %**	**moisture %**
Bone meal	1500	2052	40.7	35.8	1.83	0.77	0.45	5.4	-	16.04	7.42	9.5
Blood meal	3020	2844	87.5	73.5	8.40	2.27	1.14	0.6	-	0.17	0.17	9.4
Meat meal (50/14/26)	2830	3234	50.0	41.5	2.40	1.05	0.60	14.0	-	8.0	3.90	6.0
Skim milk powder	2490	3438	34.8	33.4	2.85	1.22	0.90	1.1	-	1.35	1.01	4.8
Feather meal (hydrolized)	3170	3415	82.5	71.8	1.57	3.80	0.58	7.5	-	0.44	0.23	8.3
Fish meal (70% c.p.)	3320	3482	70.0	65.8	5.39	2.66	2.03	8.0	-	3.50	2.60	8.0
Whey powder (delact. 20% c.p.)	1890	2924	20.0	18.0	1.44	0.72	0.32	1.7	-	5.00	1.60	2.5
Miscellaneous												
Citrus pulp	-	2960	6.3	2.4	0.16	0.14	0.06	2.3	11.9	1.40	0.12	9.9
yeast (beer)	2860	2954	45.3	39.4	3.35	1.18	0.72	1.0	3.1	0.26	1.50	6.3
Grass meal (less than 16% c.p.)	1010	1796	13.7	7.7	0.64	0.36	0.26	3.2	25.4	0.49	0.31	8.5
alfalfa meal (sundried)	700	1538	10.1	5.3	0.47	0.26	0.23	1.8	27.4	1.78	0.25	10.4
molasses (cane)	1800	2397	4.0	1.6	0.02	0.02	0.02	-	-	0.67	0.05	26.7
Minerals												
Dicalcium phosphate	-	-	-	-	-	-	-	-	-	24.0	18.0	1.0
Monocalcium phosphate	-	-	-	-	-	-	-	-	-	16.0	22.5	1.0
limestone/ shells	-	-	-	-	-	-	-	-	-	38.0	-	1.0
salt (NaCI)	-	-	-	-	-	-	-	-	-	-	-	5.0
Single Amino-Acids												
L-lysine HCI	3730	3721	94.5	94.5	78.0	-	-	-	-	-	-	1.5
DL-metionine	4360	2721	58.0	58.0	-	99.0	99.0	-	-	-	-	0.3

Maximum inclusion rates poultry feed, Safe maximum recommended percentages of ingredients in poultry rations

Ingredients	Animal (category)						
	starter 0-6 wks	grower > 6 wks	rearing > 14 wks	layers	broiler	broiler parent stock.	remarks
Alfalfa meal	5	5	5	5	5	5	High fibre, only use 2.5% for layer
Barley	20	30	45	50	10	50	Low fibre, low energy, not for broiler
Barley: by-products	10	10	15	15	10	15	
Beans; toasted	5	5	5	5	5	5	ANF lactin present
Blood meal	2	2	2	2	2	2	Taste not good
Coconut cake / meal	5	5	5	5	5	5	depending on aflatoxin
Fats / oils	5	5	5	5	8	5	Laxative, technical problems with mixing
Feather meal	2	2	2	2	2	2	Digestion problem
Fish meal	10	10	10	5	5	5	Smell
Groundnut cake / meal	5	5	7.5	10	5	10	depending on aflatoxin between 5 – 30%
Maize	60	60	60	60	60	60	white meat broilers 10% max.
Maize Bran	20	30	30	30	15	30	Fibre, Germ and high oil
Maize gluten meal	10	10	10	10	10	10	As a colorant
Meat & bone meal	6	6	6	7	6	7	Ca, P ratio not balance; high Ca
Millet	20	20	20	20	20	20	High fibre
Molasses	3	3	3	3	3	3	Sugar is laxative, High potassium
Oats	20	20	20	20	10	20	High fibre, low energy
Peas	5	5	10	10	5	5	ANF tanin
Sesame cake / meal	15	15	20	20	15	20	High methionine
Bone meal	7	7	7	7	7	7	Ca, P ratio, 7% needed
Cassava	20	30	30	30	30	30	Dusty, In mash feeds 10% less than mentioned
Rapeseed meal	5	5	5	5	10	5	ANF
Soybean full fat	20	20	20	20	20	20	Well tested, Not more due to oil
Soya oil	5	5	5	5	5	5	High oil
Rice bran	10	10	10	10	10	10	depending on CF level: < 9 cf 30% 9 – 15 cf 20% and > 15 cf 10%
Sesame cake / meal	15	15	20	20	15	20	High methionine
Sorghum	30	30	50	50	30	50	ANF tannin, not more than 10% if don't know tannin level
Soybean meal	35	35	35	35	35	35	Well taste, as much as you like
Sunflower cake / meal	5	5	5	5	5	5	non dehulled, high fibre 40% CF
Sunflower cake	10	10	10	10	10	10	partly dehulled, 30% CF
Sunflower cake	15	15	15	15	15	15	dehulled, 20% CF
Sweet potatoes	10	10	15	15	15	15	Sugar laxative
Pure lysine	0.10	0.10	0.10	0.10	0.10	0.10	
Synthetic methionine	0.20	0.20	0.20	0.30	0.30	0.30	
Wheat	30	40	50	50	30	50	It is coagulate, High viscisity

Experiment 02
Study on feed mill operation practices

In the production of compound animal feeds there are always four main functions that have to be performed:

- **collecting of raw materials** which includes such operations as transporting, receiving, cleaning, drying and storage;
- **modifying of raw materials** to allow proper mixing and to improve digestibility. This can include operations like grinding in a hammer mill but also flaking in a roller mill;
- **blending and mixing of the ingredients** to obtain the desired formulation(s), this includes the operations weighing or volumetric dosing, and mixing;
- **delivering the compound feeds** produced. This will include operations like weighing, bagging, storage and transportation to the farm.
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In addition to these four essential functions, **modification of the mixed products** by **pelleting** may be part of the production process. An outline of a combination of operations and the order in which they are executed is given by a **Block Flow-chart.**

The general block flow-chart shown in figure 1 shows the operations generally used in the production of compound animal feeds (complete feeds or concentrates) in the sequence they are usually executed.

While a block flow-chart shows the sequence of operations and the flow of the product, it does not indicate the scale of production and the type of equipment used. This information which is also specific for every feed mill is usually shown in a so-called **Flow Diagram.**

Feed mill operations

In the following sections a general outline is given of the various operations in small and medium scale feed mills.

Transport and reception

In developing countries raw materials of farm origin (e.g. grains, oilseeds) will usually be packed and transported in bags. Industrial by-products may be in **bags** or in **bulk.** Transport is generally done by truck. When the raw materials arrive at the factory they can be either manhandled or conveyed mechanically into the raw material warehouse or silos. Since quality control is an important part of feed compounding and the price or value of the raw materials depends largely on their composition and condition, checks should be made on the weight and condition of the incoming raw materials and samples should be taken for laboratory analysis, where possible.

Cleaning and drying

In small-scale feed mills, the provision of special equipment for cleaning and drying the raw materials is generally not worthwhile. Losses due to damp, dirt and contamination can usually be avoided by limiting the period of storage and maintaining proper storage conditions. In medium scale feed mills simple facilities for cleaning and drying, such as a sieve-machine, winnower and sack- or bin drying equipment, may be installed.

Storage of raw materials

After reception, raw materials should be stored under conditions, which ensure that they are kept dry and free from insects and rodents. In small mills they are often stored in bags. The storage space should have a dense (concrete) floor, but roof and walls need only be lightly constructed provided they are pest- and waterproof. In larger mills bulk storage in concrete, steel or polyester-glass fibre silos or on concrete floors with partitions is more appropriate. The choice between bag- and bulk-storage depends on local circumstances.

Blending
With blending (or dosing) is meant the assembling and measuring out of the required quantities of (solid) raw materials into a batch of the desired composition. In most feed mills blending of those raw materials that need to be reduced in particle size, takes place before grinding, while the already fine enough raw materials are added after grinding. The complete batch is then subsequently mixed.

Grinding
A number of raw materials, including cereals and oilseed cakes, need grinding to prepare them for blending and/or mixing and to make them more digestible to the animals. The type of grinding machine usually employed in feed mills is the **hammer mill**. Other types of grinders such as **roller-mills** could be employed.

Mixing
The purpose of mixing is to obtain a feed mixture, which is sufficiently homogeneous to ensure that the animals are offered the different nutrients in the desired proportions. Mixers are vertical or horizontal bins in which a revolving screw or set of paddles mix the solids until an even mix is obtained. The mixer can be considered as the heart of the feed mill as these machine effects the essential compounding of the feeds.

Pelleting
Pelleting is a process that can often be omitted in developing countries, since in many situations the costs involved will outweigh any consequent benefits in higher nutrient intake or cheaper distribution. Producing good quality pellets requires an installation consisting of a molasses mixer, a conditioner, a pelleting press and a pellet cooler. Addition of steam improves output and pellet quality. It is, however, also possible to produce pellets with just a simple small press and addition of water only.

Storage of mixed feeds
In very small feed mills bags are directly filled from the mixer and the feeds are then stored in bags. In larger mills the feeds are usually stored in bulk after mixing and/or pelleting. From this bulk storage they can be transported in bulk or packed in bags. The storage period is usually much shorter than that of the raw materials. Normally a stock of 2-7 days production is sufficient.

Bagging and bulk delivery
Compound feeds in meal or pellets can be distributed in sacks. These may be jute bags or bags of woven nylon which are closed by tying or sewing. Self-closing bags of paper or plastic are very convenient but costly as they can be used only once.

Bagging and weighing the bags can be done completely manually, but a simple bag-scale makes bagging and weighing already considerably more efficient. In larger mills semi-automated bag-scales will be required.

Bulk delivery is appropriate for large farm operations. The feeds are then transported in bulk-tankers, box-trucks or tractor-drawn bulk trailers.

In order to guarantee a regular good product quality it is important to sample the ready feeds before delivery. Samples can then be analyzed in a factory laboratory or independent laboratory.

Buildings

The building to house the machinery and storage will depend to a large extend on the particular circumstances of the mill. In general the building must be capable of being kept clean and provision should be made for keeping the dust level as low as possible since it can affect the operation of the machinery and the health of the people working in the plant. The required space for storage of raw materials and feeds determines largely the size or the factory buildings. In most environments equipment should be totally enclosed in a light structure; where the climate is suitable, however, the machinery can also stand in the open or under a roof only. A concrete floor, which can be swept, is usual. It should be laid down to the machinery plan as pits and foundations are usually required.

Services

A supply of electricity is always necessary except for very small milling units. Where there is no reliable public supply a (stand-by) generating plant will be required. Water is required only for direct addition and/or raising of steam in pelleting. Only very exceptionally it is also used to sprinkle raw materials before grinding or during mixing.

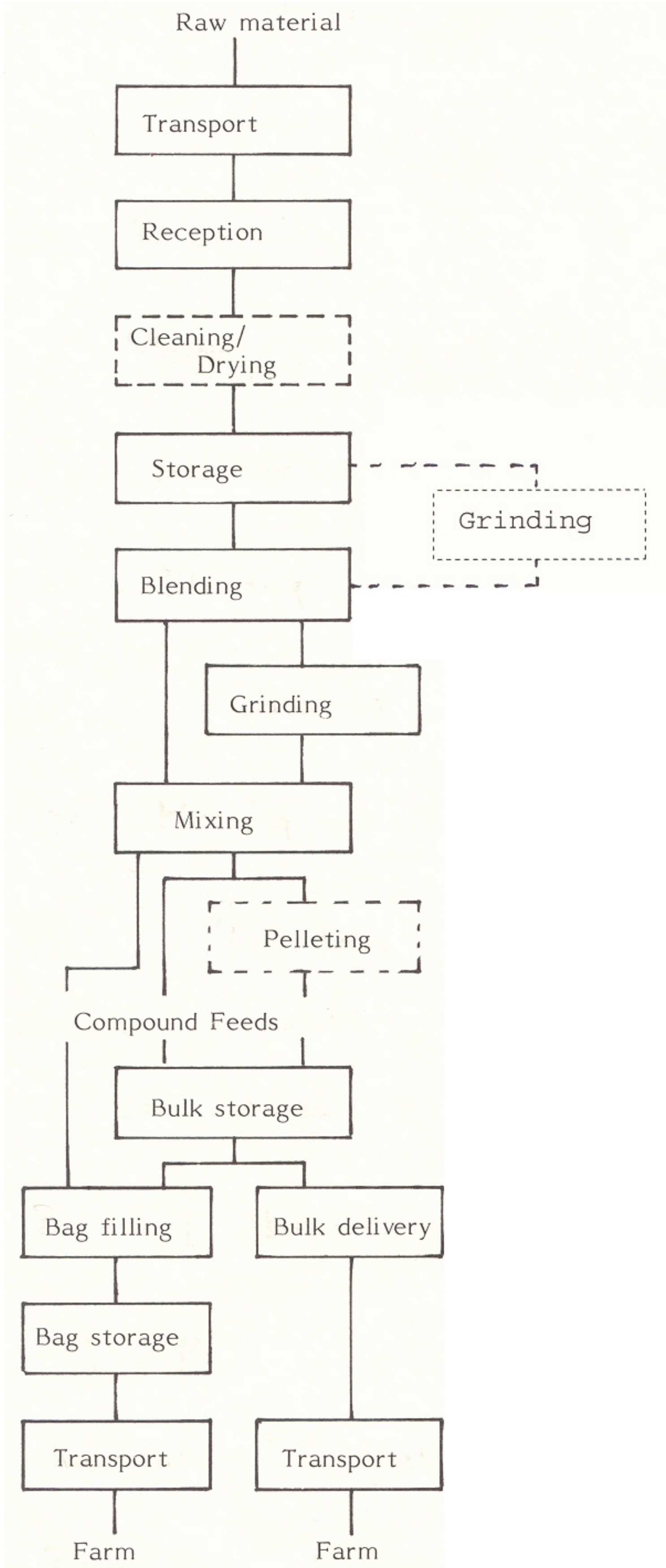


Figure: Block Flow-chart for Compound Feed Production

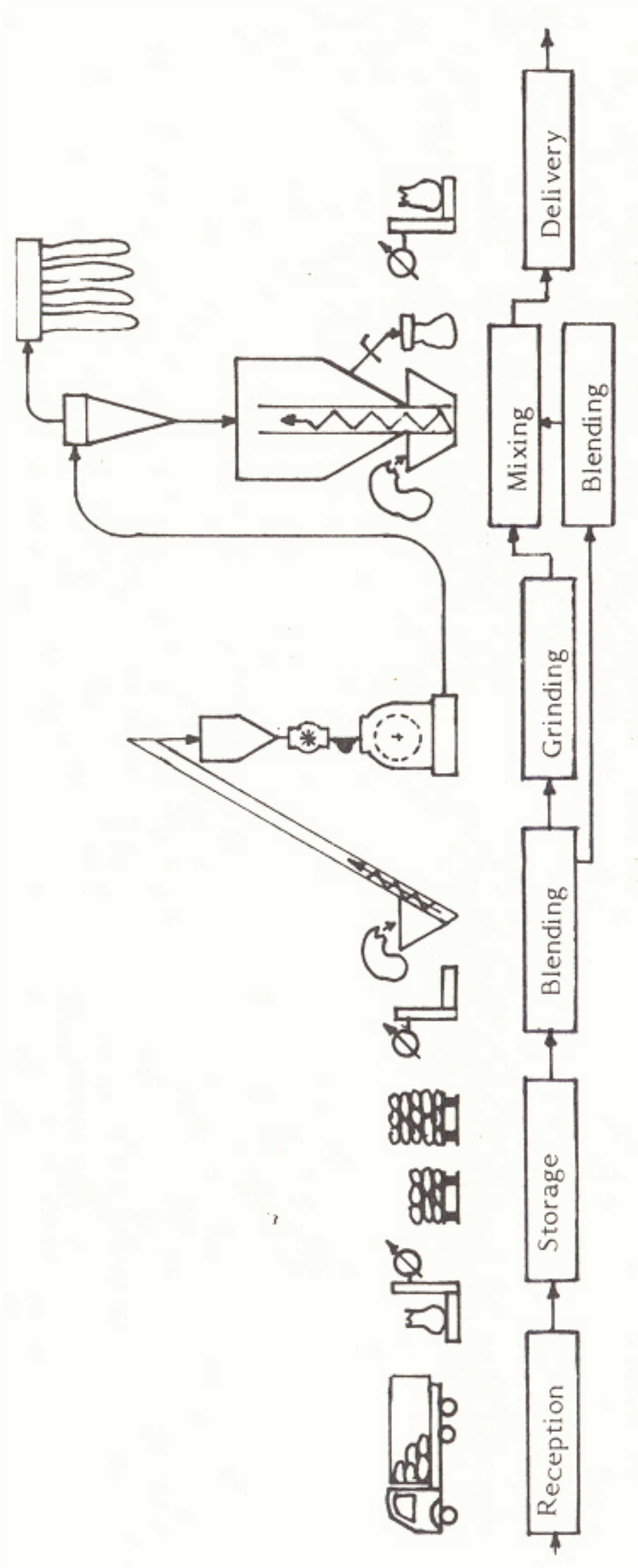


Figure: Block Flow Diagram for Compound feed Production

Experiment 03
Study on Blending/dosing of feed ingredients

In compound feed production, blending is called the **measuring out (proportioning or dosing) and assembling** of the required quantities of the dry raw materials to obtain the desired composition of the feed(s).

In formulating the desired composition(s) the quantities of raw materials are always expressed in units of weight or percentages.

The actual measuring out can be done:
- Gravimetric (by weighing)
- Volumetric (by volume)

Weighing is accurate and can be used for all types of materials; however, the equipment used is relatively expensive and sensitive to damages.

Volumetric dosing has the advantages that the equipment used is relatively inexpensive, simple and robust.

Both gravimetric and volumetric blending may be done either:
- Batch wise or
- Continuous

In batch wise blending the different ingredients are measured out and assembled into a batch of a certain amount (250 kg - 3 ton) before further being processed.

In continuous blending the different ingredients flow in measured proportions and simultaneously, directly to the next processing operation (i.e. grinding or mixing).

Gravimetric blending

The equipment used for gravimetric blending consists of a **weighing scale** with devices on top to control the amount of product flowing into the container on the scale.

Scale types

For blending by weighing different types of equipment are available:
- Platform scales
- HOPPER SCALES (MOVABLE, FIXED, LONG BIN)
- Belt scales

The simplest method of blending by weighing is using a platform scale to weigh out the different ingredients in bags or buckets. This is suitable for batch wise production at a small scale, but also for addition of micro-ingredients (e.g. premixes minerals) in larger scale production.

The capacity of platform scales does usually not exceed 100 kg. For micro components small scales are used to obtain acceptable accuracy of weighing.
Hopper scales consist of a hopper, which is suspended on a weighing mechanism. It has a slide valve or discharge device at the bottom to discharge the materials into a conveyor (or directly

into the grinder) after weighing. Hopper scales are suitable for bulk raw materials. In the case of bagged materials they are filled by hand or with a simple conveyor.

Belt scales consist of a conveying belt on which the materials to be dosed are discharged from the storage bins through extracting screws, rotating-lock valves or other devices. At the end of the belt a weighing sensor records for each ingredient the amount that has passed. Since belt scales are relatively complex in construction and operation and require automated control, they are suitable only for large-scale operations.

Typical application of different types of scales for dosing	
Platform scales	bag handling batch wise small scale and micro-ingredients
Fixed hopper scales	bulk from bins and bags batch wise small and medium scale maybe automated
Movable hopper scales	bulk from bins batch wise medium scale
Long-bin scales	bulk from bins batch wise medium and large scale maybe automated
Belt scales	bulk from bins batch wise or continuous medium and large scale automated

Volumetric dosing
Volumetric dosing is used for macro ingredients only and can be done by:

- Counting bags of known content
- Mechanical flow control (screw conveyers, vibrator conveyers)

In small scale feed mills dosing of the macro-ingredients is very often done simply by tipping a given number of bags with a known content into the bin above the grinder or into the mixer. For volumetric dosing from silo's or bins extracting conveyers can be used.

In batch wise dosing these devices have a fixed speed and therefore a fixed capacity. (m^3/min or kg/min) The amount to be dosed thus depends on the time the screw/vibrator is switched on. In continuous dosing the ingredients from several discharging conveyers flow together into a (pneumatic) conveyor and the amount dosed for each ingredient is then determined by varying the speed of the device or the open surface of a slide valve.

Screw conveyers can be of a standard design as for transport purposes. Sometime special shapes are used to obtain an even flow from the bin without interruptions. For this reason an increasing pitch or an increasing diameter can be used.

Vibrator conveyors operate on the principle that particles bounce on a rapidly vibrating surface; as the vibration is eccentric the particles will move in the direction of the longest stroke. The capacity of these conveyors depends on the thickness of the layer of material and the frequency and amplitude of the vibration.

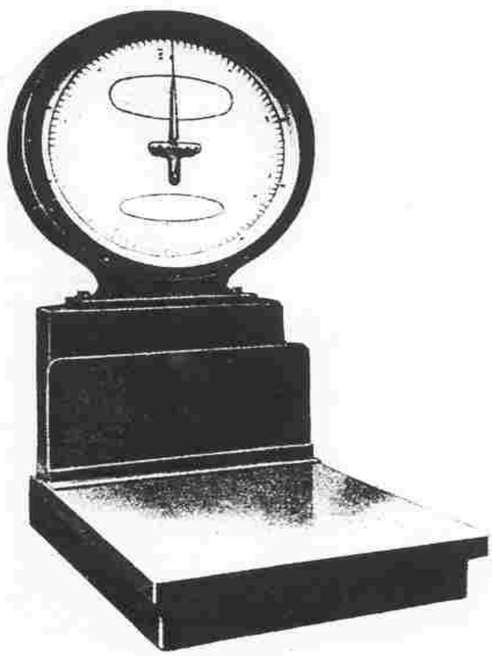


Figure: Platform scale

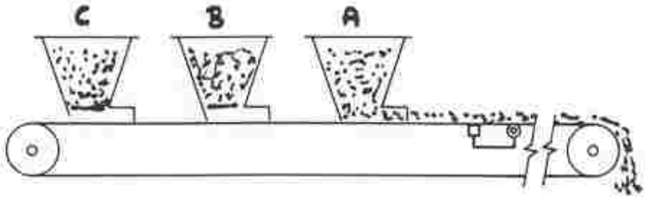
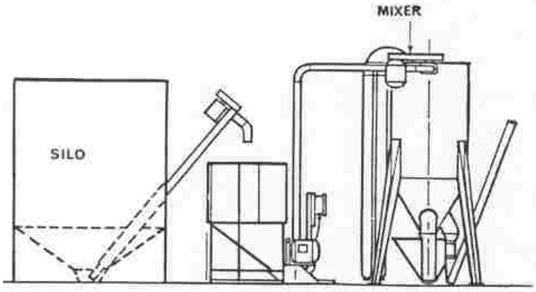
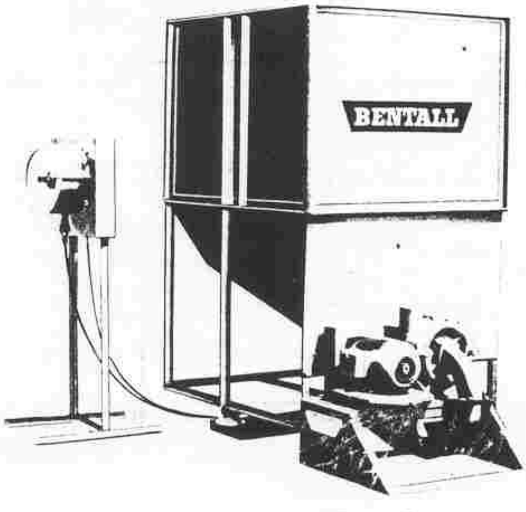
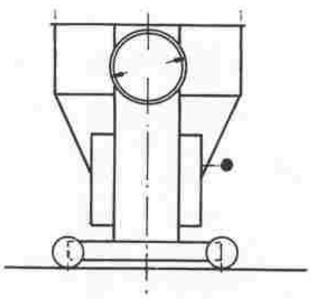


Figure: Belt weigher



Fixed hopper-weigher





Movable hopper-weigher

Figure 33 Hopper scales

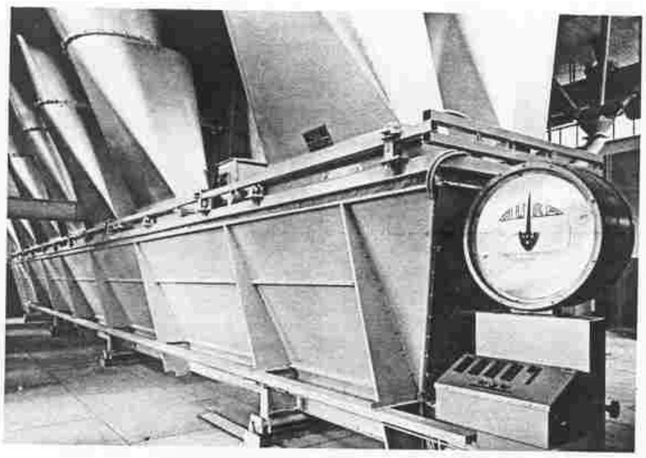


Figure 34 Long-bin scale

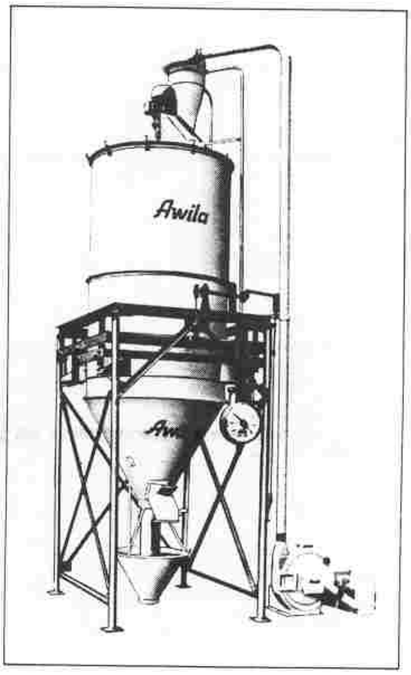


Figure 35 Mixer on weighing mechanism

Experiment 04
Study on Grinding of feed ingredients

Grinding means modifying of feed ingredients by size reduction for inclusion in the production of compound feed (i.e. mash, pellet, crumble).The raw materials used in compound feed production partly originate from arable farming; partly they are by-products from agro-industrial processes (e.g. oilseed cakes, meat and bone meal). In many cases they need **modifying by size reduction** (grinding) before they can be included in animal feed.

Size reduction by grinding aims at:

- **Improvement of digestibility** of the ingredient by increasing the surface area of the particles. Grinding too fine will reduce the acceptance by the animals and create problems of excessive dust. Poultry feed in general should be less fine than pig feed. Layer performance can show even better results with partly ungrounded particles.
- **Improvement of mixing** when particles to be mixed vary much in size (and mass) it is difficult to obtain a homogeneous mixture. Homogeneity of the feed mix is important because the animal to be fed should obtain all the ingredients in the proper proportions in each "meal" offered. Moreover, when particles in a mixed feed (in meal form) vary much in size, segregation of the feed may occur during transport inside the feed mill or from feed mill to farm.
- **Facilitating pelleting** of the feed. When particle size differs much in a mixed feed it is difficult to obtain good pellet quality.

There are many different designs of size reduction equipment; these can be categorized according to the forces predominantly generated in the mill:

- **Impact;** the particles to be reduced in size and hit by a fast moving metal part and thrown at high speed against a wall. They break up in smaller particles through the impact forces (e.g. hammer mill).
- **Attrition**; the particles are reduced in size by friction forces between two surfaces moving at different speeds (e.g. disc-mills or roller mills with discs or rolls running at **different speed**).
- **Compression**; the particles are compressed until they break (e.g. flaking in roller mills with rolls running at **equal speed**).

Grinding requires generally high **energy input**. Much of the energy used for cutting the particles is lost in **generating heat**. Grinding equipment is often **cooled by air**. The material always passes the grinder in bulk and the precise action of the size reducing of the individual particles cannot be predicted (i.e. **grinding is a random process**). The result of a grinding operation is therefore a mass of particles with a "distribution of particle sizes". The **uniformity** of this distribution depends on **the characteristics of the materials** in the formula and of several **details in the grinder operation**.

Typical figures for the mean particle size of complete feed are:

Pigs	0.5 - 0.7 mm
Poultry	0.7 - 0.9 mm (broiler)
	0.9 - 1.5 mm (layer)
Cattle	0.8 - 1.0 mm

Grinding equipment
Grinders using impact
The machine most commonly used in compound feed production is the **hammer mill** because of the relative **low investment costs** and the **high capacity**.

A hammer mill consists of a **steel chamber** in which a **rotor with hammers** rotates at a high velocity. Part of the chamber wall can be fitted with a **break-plate**, while remainder consists of a **perforated steel screen**. The material enters the chamber from the top and is hit by the fast rotating hammers against the break-plate. The particles are broken up by the impact of the hammers and/or the break-plate.

Particles that are small enough pass through the screen-openings to the outlet. Those particles that after the first impact are not yet sufficiently small are retained on the screen and hit again by the hammers. The hammers are suspended from the rotor on pins. The tips of the hammers in a standard hammer mill have a **velocity** of approximately **100 meters per second.** There are also mills with 2 speed motors, so hammer speed is reduced to about 50 m/s. The result of the lower speed during grinding of whole grains is a coarser product with less fine particles (dust). In addition to the hammer mill itself the whole grinding installation usually comprises the following parts:
- A **storage bin** above the mill (grinder bin)
- A **feeding device** for controlling the feed rate
- A **magnet** and a **stone-separator** for removal of ferro-metals and stones from the entering material;
- The **hammer mill** itself
- An **aspiration system** for cooling of the mill and assisting the flow of fine particles through the screen
- A **discharge system**

Hammer mill
The hammer mill itself comprises of an **inlet, break plate(s)**, **rotor and hammers**, a **screen** and an **outlet**.
- The **inlet** opening may be **tangential** at the circumference of the mill chamber, **axial** at the heart of the rotor and **radial** at the top of the chamber.
- The purpose of a **break plate** is to **reduce the speed of the product** in order to get a maximum effect of the hammer speed when touching the particles.
- The **rotor** of a hammer mill may consist of a number of circular plates mounted on a shaft but may also be made of solid steel or be an open ring as is the case in ventimills. The hammers are attached to the rotor by means of **removable hardened steel pins**, which fit through holes in the hammers.
  The **hammers** in a hammer mill usually are flat strips made of steel with a **hardened surface**.
- The **screen** of a hammer mill serves to **regulate the maximum particle size** of the product. The perforation of the screen is generally round with a diameter ranging from 1.5 to 12 mm.
- The **outlet** of most hammer mills is centrally below the screen. The product falls down into a collecting bin or is taken by an air stream if the transport to the next step is done pneumatically.

Capacity of hammer mill installations

The capacity of a hammer mill installation is determined by the **characteristics of the product(s)** and by the **characteristics of the installation**.

The main **product characteristics** influencing the capacity are:

- **Hardness**, **brittleness** and **fibre content** of the ingredients
- **Moisture content** of the ingredients
- **Percentage fines** that are already present in the ingredients
- **Desired average particle size** in the feed(s)

The equipment characteristics that determine the capacity of the installation are

- the **condition** and **size** of the **break plate**
- **condition** of the **hammers**
- total **surface area** and **open surface** of the **screen**
- **power** installed
- **capacity** of the **aspiration system**

Grinders using attrition and/or compression

Breaking rolls

Some raw materials, which are received in large particles such as oilseed cakes or tapioca chips, may require size reduction before storage in silo-bins in order to facilitate flow and blending. For this purpose breaking rolls can be used. In these machines the material is **crushed between one roll and a fixed plate** or **between two rolls that slowly revolve in opposite direction.** (Approx. 1 m/s) The roll(s) are grooved or have projecting ridges or teeth. The size reduction is mainly by compression forces. Energy consumption is relatively low.

Roller mills

Roller mills can be used for **flaking products** or for **grinding**. Flaking is done with a **high oil content product** (e.g. oilseeds) or for **opening up fibrous grains** (e.g. oats). The product is compressed between two smooth or riffled rolls. The rolls run at **the same speed in opposite direction**. For grinding e.g. maize the rolls run at **different speed in the ratio** 1:1,5 - 2.0. Compared to hammer mills **energy consumption** is much **lower** because of the lower speed. **Aspiration is not needed** and the product contains **less fine particles** if the rolls are having sharp grooves (riffles). However the **capital investment is much higher** and the **maintenance costs** can also be quite **high** if the product contains (small) stones.

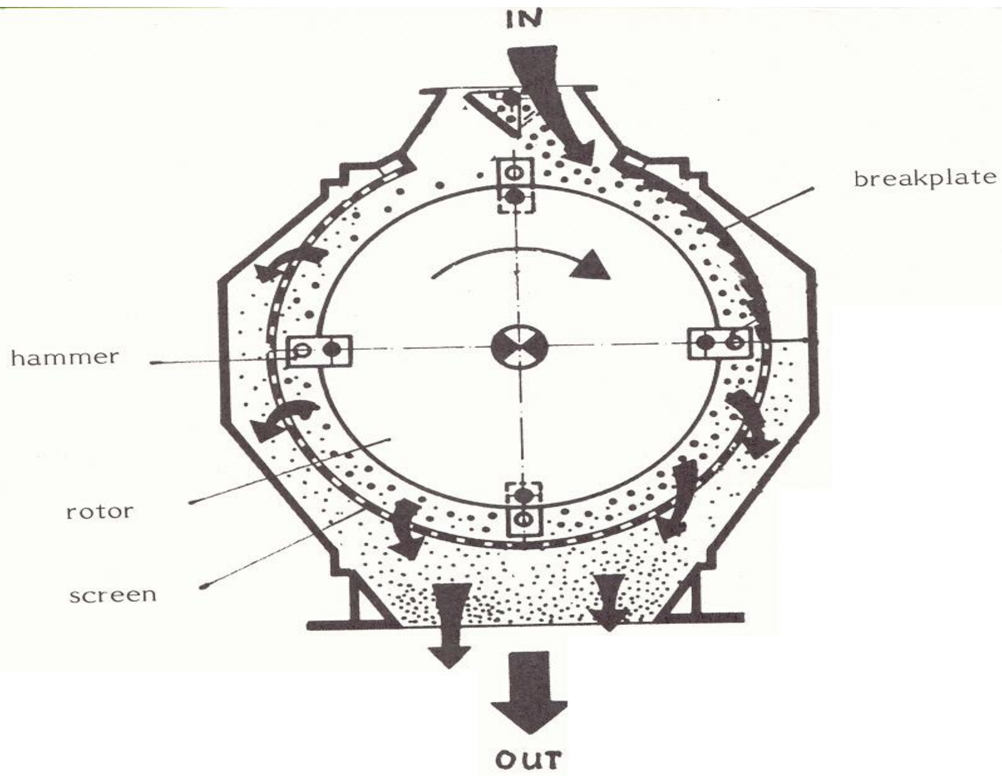
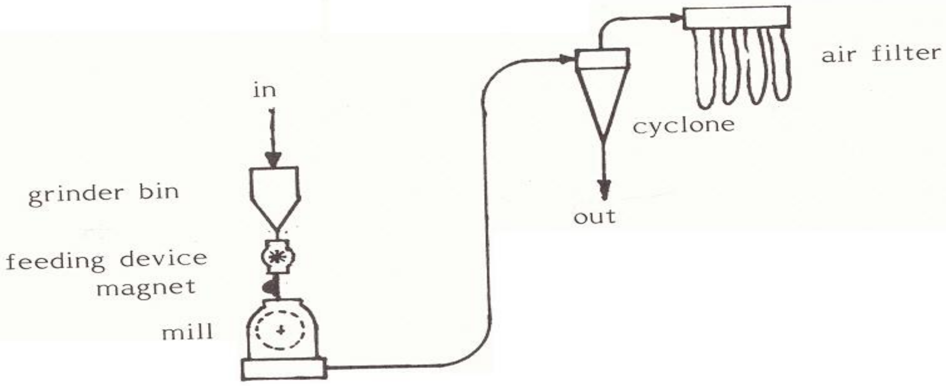


Figure 42: Hammermill.



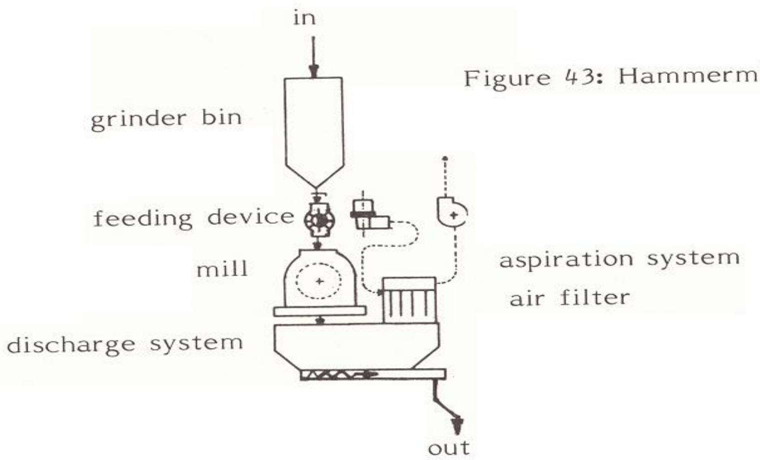


Figure 43: Hammermill installation.

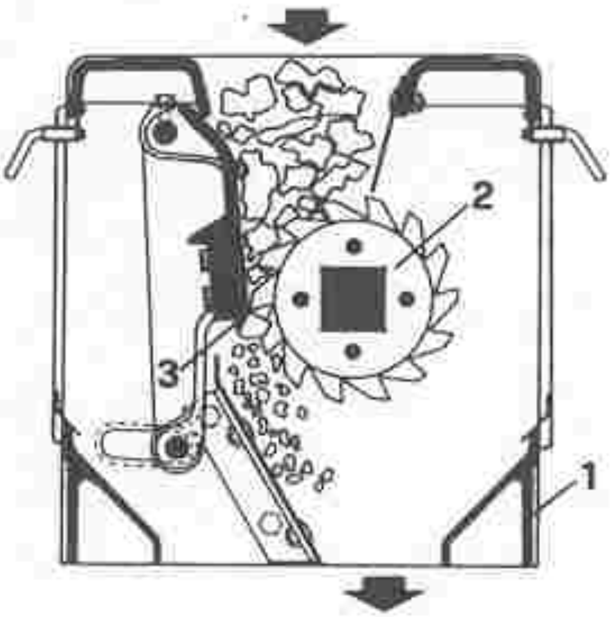


Figure: Breaking roll

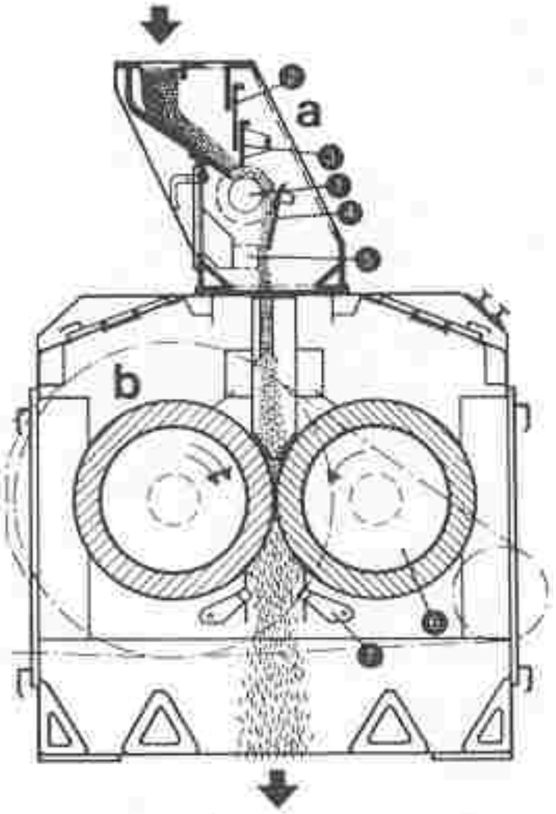


Figure: Rollermill

Experiment 05
Study on mixing of feed ingredients

Mixing is the combining of different components into a more or less homogeneous mass that cannot easily be separated again. In compound feed production we deal with mixing of:

- Dry ingredients only
- Dry ingredients with a relatively small proportion of liquid (e.g. meal with less than 10 % molasses)
- Wet ingredients (e.g. preparation of slurries)
- Liquids with liquids (e.g. fat, vitamins, oil)

Of these possibilities the first two are most common. Mixing can be done:

- Batch-wise
- Continuous

Nowadays mixing of dry ingredients is generally done in batches. Mixing of molasses is normally done only in conjunction with subsequent pelleting of the feed using continuous mixers. In compound feeds we make a distinction between:

- Macro-ingredients of which the formulated content is normally more than 5% of the total feed
- Micro-ingredients of which the formulated content can range from 0.01‰ to 5% of the total feed.

Homogeneity and quality

Mixing of liquids with other liquids follows definite rules and may lead to completely homogeneous mixtures. The result of mixing of dry solids, however, cannot fully be predicted and is never a completely homogeneous mixture (i.e. mixing is a random process).In other words, when a large number of samples from a solid-solid mixture is analyzed; there is always a variation in the content of each component in the different samples. When the homogeneity is high, this variation is small. In assessing the homogeneity of compound feeds there are two factors to be considered:

- Permissible variation in the content of the components
- Size of the sample

The result of mixing depends on:

- Characteristics of the ingredients to be mixed
- Characteristics of the equipment used
- Time of mixing

Ingredient characteristics

The characteristics of the ingredients that influence the mixing process are:

- **Particle size** (distribution) : The smaller the particles, the higher the chance to obtain a good homogeneity. The more uniform the particle sizes are, the better homogeneity level can be reached.
- **Particle shape** and surface **structure**: Irregular shaped particles have higher friction on each other and therefore mix more difficult but once mixed they will not segregate easily again. The same is valid for particles with a sticky surface. (E.g. high fat content)
- **Specific density:** A high variation in specific density between materials to be mixed is unfavourable for reaching homogeneity and may lead to easy **segregation**. Specific density of animal feed ingredients ranges from 1.0-2.5 kg/dm3. (Animal fats 1.0; vegetable material 1.4; minerals 2.4-2.5 kg/dm3)

- **Moisture content** and **static charge:** Particles that are **hygroscope** will easily attract moisture during storage and transport. They can form lumps in the feed. Like products with high moisture level, problems can be avoided by grinding them together with the dry ingredients. Very dry particles may become charged with static electricity and will stick together and hamper achieving homogeneity.

Machine characteristics

Its construction and way of operation determine the influence of the mixing equipment on the mixing result. Factors of influence are:

- **Transport effect:** The more irregular the directions of the movements in the mixer are, the shorter the time to obtain an acceptable homogeneity.
- **Speed of movement:** A higher speed of the mixing elements (e.g. paddles, screw) gives faster and better mixing, especially of "sticky" materials.
- **Wall surface structure:** A rough surface leads to more irregular movement in the mixer and thus to better mixing.
- **Conduction of static electricity:** Connecting of (metal) mixer walls to earth reduces the risk of lumping of statically charged particles.
- **Level of filling of the mixer:** Horizontal mixers have a maximum and minimum level of filling beyond which the mixing effect becomes insufficient. Vertical mixers can handle a wider filling range.

Mixing time

The time necessary to reach an acceptable homogeneity is determined by:

- **The type of mixer employed**: In standard vertical mixers a mixing time of approximately 15 minutes is required to obtain a good mix. In horizontal mixers the mixing time can be only 3-4 minutes, because the mixing elements induce an intensive movement all over of the total volume of the mixer vessel.
- **The degree of pre-mixing** already achieved beforehand: Premixing can be done deliberately (e.g. micro components), but may also be the result of the order of dosing/blending the various ingredients, the use of internal transport equipment (e.g. screw conveyors) and of blended grinding.

Segregation and contamination

After mixing is completed, the mixed feed(s) will undergo a certain amount of handling before reaching the animals to be fed. This may cause segregation of feeds (in the form of meal) and contamination. Segregation means that the level of homogeneity goes down. It is promoted by:

- Falling down into (deep) silo-bins
- Shaking movements (e.g. in bulk trucks)
- Pneumatic conveying

Especially compositions with large differences in particle size and specific density (e.g. limestone in layer mash) are prone to segregation. Segregation can be avoided or reduced by pelleting and/or addition of liquids. (E.g. fat and molasses).With contamination is meant the inclusion of materials in the mix that do not belong there according to the formulated composition. Contamination usually occurs through:

- Insufficient clean-out of silo's and bins (angle of slide), conveyors, mixers and scales
- Returning of collected dust from dust filters into other batches
- Mistakes in blending by adding wrong ingredients
- Contaminated raw materials

Liquid addition

It is very difficult to add molasses into dry meal on the slow moving batch mixers as this would lead to lumps in the meal. Homogeneous mixing of molasses therefore requires fast moving (continuous) mixers. The level of addition depends on the ability for adsorption of the dry ingredients. Usually 4 –5 % is the maximum to keep the meal free flowing. Addition of fats is usually somewhat easier than that of molasses provided the fats are available as a thin liquid. Depending on the type of fat and the climatic conditions this may require heating of the fat prior to mixing. Liquid fats can be added to dry meal in horizontal or vertical batch mixers to a maximum percentage of 5- 8 % by gradually spraying it on the meal during mixing. In case molasses is also added fat can be added simultaneously on the fast rotating molasses-mixer.

Mixing equipment

A) Vertical mixer

A vertical mixer consists of a cylindrical bin with a conical (or hopper) shaped bottom. Inside the vessel is a vertical screw-conveyor which moves the material upward centrally; the material subsequently flows downward at the wall of the vessel. The mixer can be filled from the top or through an extension of the screw-conveyor into a conical dump-hopper at the bottom of the mixer. After mixing the material is discharged through an outlet at the bottom or at the side of the vessel. Depending on the shape of the vessel and the purpose of mixing the mixing time varies from 15 minutes for normal feeds to 30 minutes for production of premixes.

Vertical screw-mixers have the **advantages** of:

- Relatively low installed motor power (5.5 kW for a 2 ton mixer)
- Low investment
- Flexible capacity utilization, as the filling-rate does not influence mixing quality.

Disadvantages are however:

- Relatively long mixing time
- Slow discharging which can reduce feed mill capacity
- Relatively high building height is required.

To increase mixing efficiency (reduction of mixing time), vertical mixers are sometimes fitted with:

- Flow diverting beams in the vessel
- Varying pitch of the screw
- Varying diameter of the screw
- An elevator outside the mixer to realize an outside circulation
- Two screws in an oval-shaped vessel. (Duplex mixer)

A specific problem of vertical mixers with a dumping hopper for filling the mixer at floor level is that there always remains a quantity of material in this hopper after discharge of the mixer. This leads to contamination and special operating procedures are required to reduce carry-over of unwanted material into the next batch.

Because of their low investment cost and simple construction, vertical mixers are particularly suitable for small and medium scale operations with a low degree of mechanization.

B) Horizontal mixer

Horizontal mixers consist of a horizontal cylindrical or U-shaped vessel in which one or two shafts are fitted with mixing blades or paddles. In the compound feed industry the so-called "ribbon mixer" which has two helical mixing blades with opposite pitch fitted to the shaft is commonly used. The mixer is filled from the top and discharged through valves in the bottom. To reduce the discharging time the bottom is usually fitted with several large valves or even the whole bottom can be opened. The last solution has the advantage that the mixer also is completely cleaned out (less contamination).Because of the more intensive contact of the mixing blades with the material and the more irregular movement; the required mixing time is only 3-4 minutes. Compared to vertical mixers the installed power is relatively high. Since the mixing time is, however, much shorter, there is not much difference in energy consumption per ton between vertical and horizontal mixers.

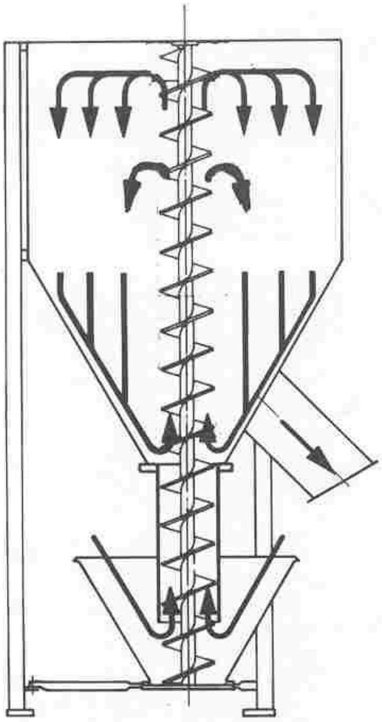
Advantages of horizontal mixers are:

- Short mixing time resulting in high capacity
- Rapid discharge
- Mixing of liquids is possible (limited to 8 % for fat and about 2 % for molasses)
- Low building height.

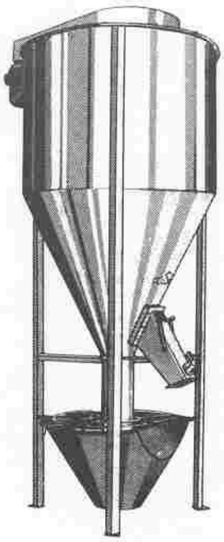
Disadvantages may be:

- Incomplete clean-out when outlet valves are small
- Higher investment because of more complex construction and higher installed power
- Filling level is limited: mixing efficiency is lost when the mixer is overfilled.

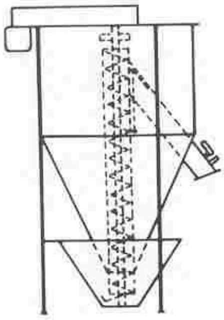
To achieve an even smaller building-height with the same volume, **double shaft ribbon mixers** are used.



A: Principle of vertical mixer.

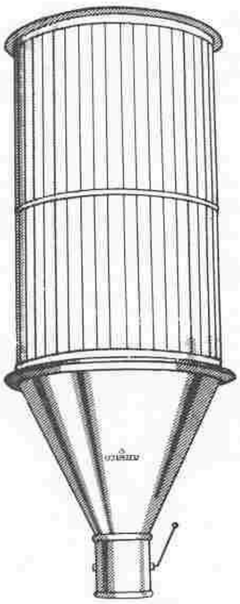


B: Vertical mixer
with extended screw.

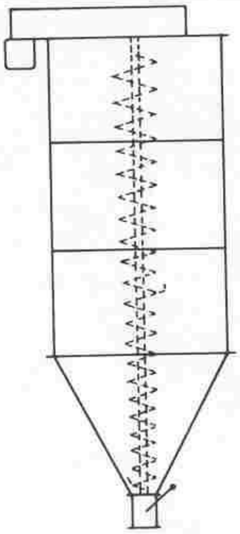


C: Vertical mixer
with top outlet.

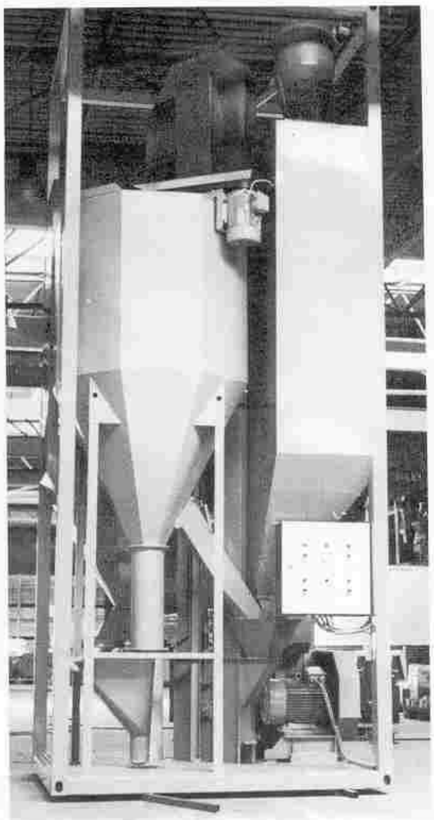
Figure 55: Vertical mixers.



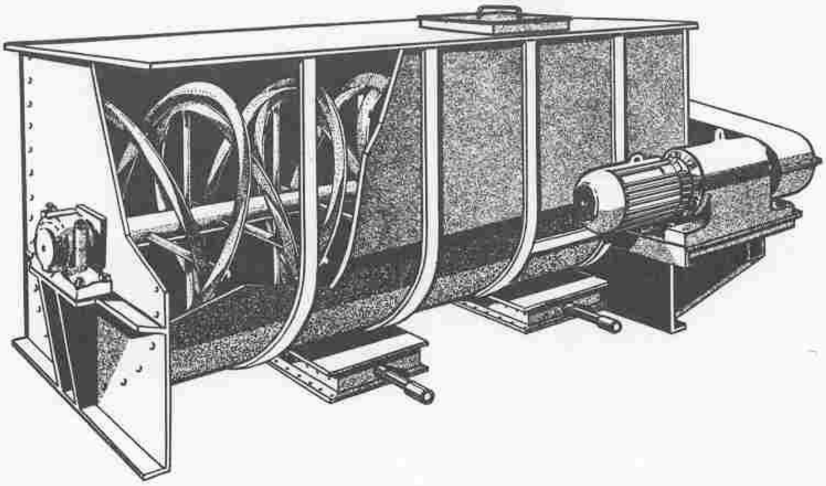
D: Vertical mixer
with bottom outlet.



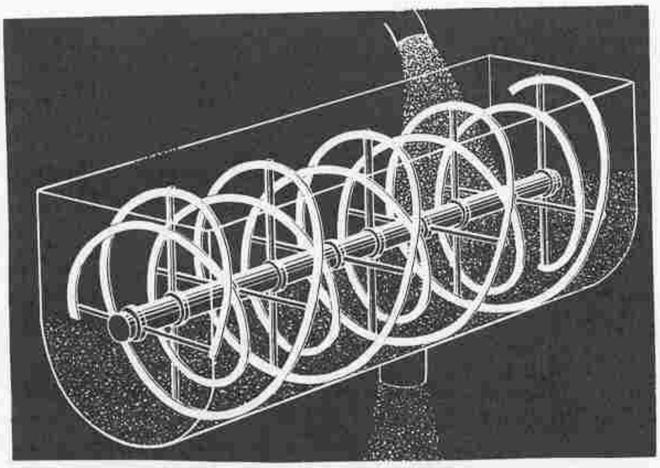
E: Same as D.



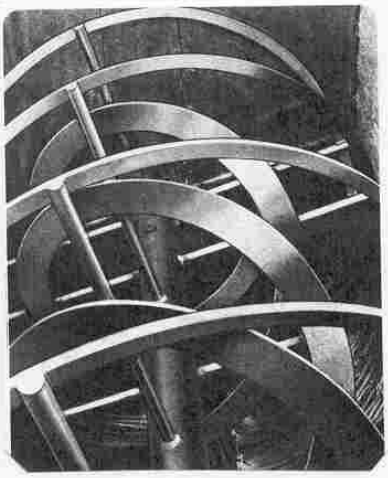
F: Container unit
with vertical mixer



A: Horizontal ribbon mixer.

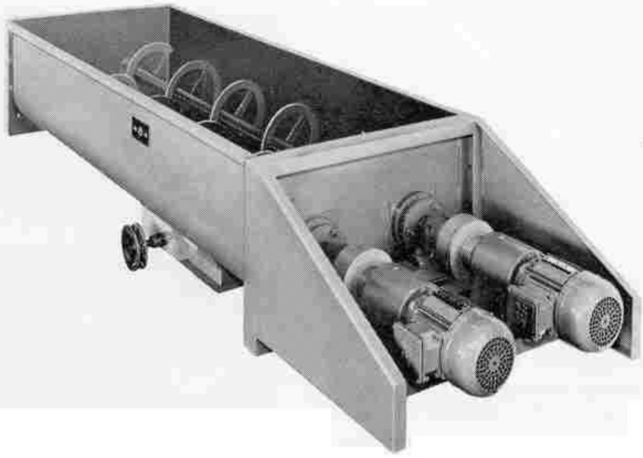


B: Principle of horizontal ribbon mixer.

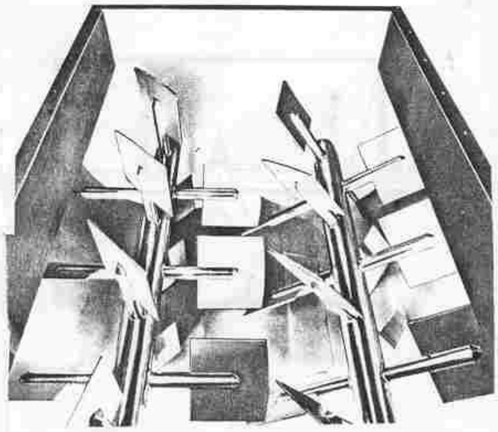


C: Double ribbon blade.

Figure 58: Horizontal mixer.



A: Double srew mixer.



B: Mixer with paddles

Figure 59: Special horizontal mixers.

Experiment 06
Study on Pelleting of feed ingredients

Pelleting is the forming of dense particles from a mixed compound feed.

Advantages of pelleting:

- Higher (bulk) density of pellets compared with meal results in lower storage space requirements and lower transport costs
- Segregation of mixed feeds cannot occur
- Dusty raw materials that are difficult to include in meal may be included in higher percentages in pelleted feed
- Heating before and during pelleting reduces bacterial count and can improve the nutritional value
- Handling the feed on the farm is easier and can be mechanized better, while there will be lower wastage in feeding
- Feed intake by the animals is faster and easier
- There is no risk of selective feed consumption by poultry

Disadvantages of pelleting:

- Pelleting installation requires considerable additional investment
- Operation requires skilled labour
- Maintenance and replacement of wearing parts (dies and rolls) entails high costs
- Energy consumption is high

The process of pelleting can be divided in four phases:

A. Conditioning of the meal by addition of liquids (water, molasses) and by heating with steam
B. The actual pelleting
C. Cooling of the pellets produced
D. Sieving pellets

Furthermore crumbling and liquid addition to pellets (coating) may be part of the pelleting process in a bigger feed mill.

A) Conditioning of meal

The conditioning of the meal is necessary to bring the meal in such a condition that a good (i.e. hard and compact) pellet can be produced. Conditioning, in fact, already commences during grinding. The reduction of the particle size during grinding will increase the total surface of the particles and thus facilitate the absorption of liquids and heat. Furthermore the porosity of the material in bulk will decrease thus making compression easier because less air needs to be removed from between the particles. The most suitable particle size (distribution) for pelleting is usually obtained by grinding on a 2-3 mm hammer mill screen. The distribution should be as uniform as possible. Too coarse particles will give pellets that crumble easily, while grinding too fine will lead to high energy consumption in grinding without improved pellet quality. After grinding the conditioning may involve the addition of liquids with the aim to improve the nutritional value as well as the pelletability of the feed. Molasses improves the energy value of the feed and the cohesion of the pellets, while addition of water and or heating with steam can increase the capacity of the pelleting press with 50 - 100 %.

Mixing of molasses and fats

Before pelleting molasses may be added to a maximum of about 12 % in two stages. After the main mixing process with molasses addition up to 6 % it is recommended that the meal should be given some time to absorb the molasses. This “ripening” usually takes place in the storage bin above the press during 15-20 minutes. Subsequently another 5-6 % is added together with steam at a continuous mixer directly above the pelleting press. Addition of fat will increase the pelleting capacity but reduces the hardness of the pellets. Additions are limited to 3 - 4% and are usually mixed at the main batch mixer.

Addition of water
Water is used to soften raw materials and to improve binding between particles. Addition can be done at the main mixer and/or at the conditioning mixer at the pelleting press. The amount is limited to the adsorption capacity of the ingredients. Any surplus of water causes blocking inside the die of the pelleting press. Usually 2-3 % water can be added.

Heating with steam
Heating before pelleting is primarily aimed at increasing the capacity of the pelleting press, while the quality stays at about the same level. Pelleting without steam is, however, possible and is often used for small capacity installations (1-2 ton/hour). Heating with steam takes place just before the meal enters the press by means of a horizontal continuous mixer. The temperatures employed range from 40-80 °C. Steam is added to the meal at a pressure of about 2 bar. Every 10°C increase of meal temperature requires about 0.6 % (by weight) of dry steam.

B) Pressing of pellets
After conditioning the meal enters the machinery for the pelleting itself. In a pelleting press the conditioned meal is forced at high pressure (up to 1,200 kg/cm^2) into narrow holes in a steel die (ring or plate) by means of one or more press-rolls. The friction of the meal at the walls of the holes ensures the compression of the meal. The compacted pellets are forced out at the other end of the holes and then cut off by a knife at the desired length. The quality of the pellets obtained depends for a big part on the pressure generated between the roll(s) and the die. Main factors influencing the pressure obtained are:

- Length of the holes in the die
- Diameter of the holes; the smaller the size, the higher the pressure
- Shape of hole-inlet; the angle of the inlet-cone can differ as well as the length
- Percentage open area in the working die-surface. A higher percentage gives lower pressure
- Feed composition like fat, sugar, minerals and moisture (steam) content

There are two types of pelleting presses: 1) Ring-die presses and 2) Plate-die presses

Ring-die presses
These presses have a die in the form of a ring, which rotates vertically around 2, or 3 rolls. The rolls can rotate around shafts, fixed inside the die. Some smaller ring-die-presses have a die which is fixed horizontally and in which a set of rolls rotates. The die is the most important part of the whole machine as it determines the quality of the pellets and the capacity of the press. It is made of hardened chrome steel drilled with holes with a diameter ranging between 2 - 15 mm. (or even more) The diameter of the holes determines the size of the pellets Dies wear out and thus have to be replaced after 1,000 - 2,000 hours of operation, which is an important cost factor.

Plate-die presses
In plate-die presses the die has the form of a circular plate which is fixed horizontally. A set of 2-6 rolls fixed to a central rotating shaft rolls over the plate to force the meal through the holes. The rolls are not mounted on eccentrics as the whole roller head can be adjusted on the central shaft to determine the distance between rolls and die. For small capacity presses often the plate-

die type is used because the dies are cheaper to produce and the spreading of meal on a small diameter vertical ring-die is somewhat more difficult than on a plate-die.

C) Cooling of pellets

The pellets coming out of the press are still hot and soft due to the conditioning and/or the heat generated by friction in the die. They will therefore require cooling and drying to improve storability and to give them sufficient hardness for handling and transport. Cooling of pellets is done with ambient air in a pellet cooler and the time required for cooling therefore depends on the ambient air conditions. In humid and hot climates cooling thus will be slower (or a bigger capacity is needed for the same output) then in moderate climates. The required time also depends on the size of the pellets; larger diameter pellets cool slower than small pellets. The cooling time usually is in the order of 15-20 minutes for 6-mm diameter pellets and about 8-12 minutes for 2-mm pellets. There are many types of coolers/dryers for pellets; the most common coolers for small and medium capacity installations are:
1) Vertical duct cooler 2) Vertical bin cooler 3) Horizontal belt

D) Sieving

After cooling the pelleted product contains fine particles, which have to be removed to improve the appearance of the feed, to improve flowability in silo-bins and to avoid wastage by the animals. Separation of fines can be done on sieving machines with screen openings of about 80 % of the pellet diameter.

Factors that influence the result of a pelleting operation:

- Type of ingredients used
- Particle size distribution in the meal
- Amount of molasses added
- Time of ripening
- Temperature during ripening
- Amount of water/steam added
- Length of the die holes
- Distance roll-die
- Speed of the die
- Condition of the die and rolls
- Load on the motor
- Cooling conditions
- Addition of binding agents

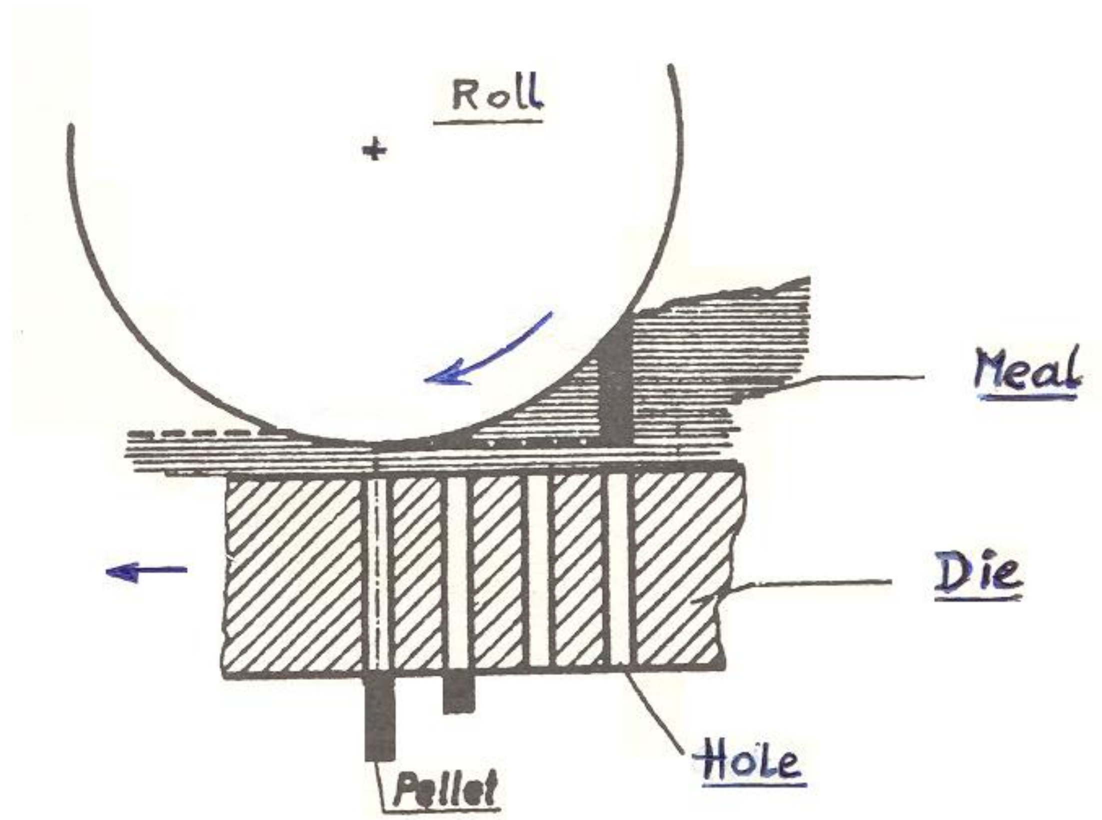
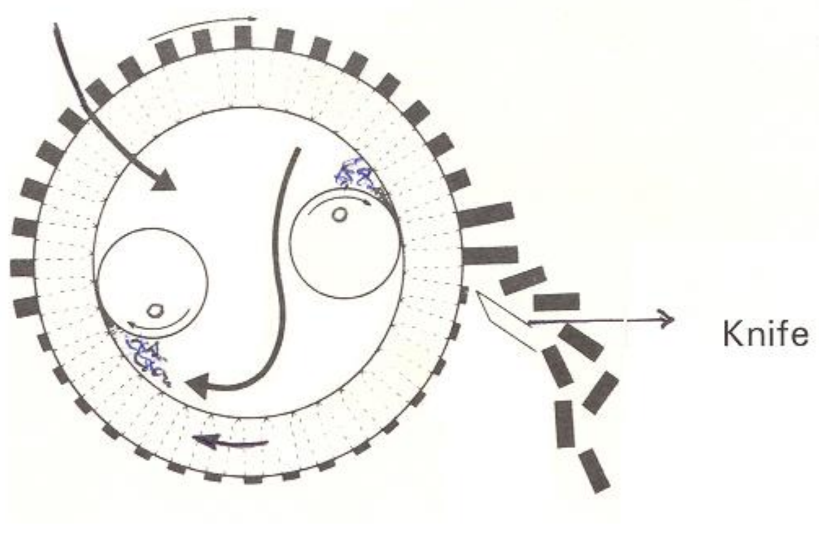


Figure 67: Principle of a pelleting press.



Experiment 07
Study on delivery of finished products

Delivery of mixed feeds as meal or pellets includes **weighing**, **bag filling** and/or **bulk handling**. Before the actual transport from the feedmill to the consumer takes place a (limited) period of **storage of the mixed feeds** in the feedmill is usually also necessary.

Bag Delivery

Type of bag

There are various types of bags that can be used for mixed feeds. In the choice of the type of bag to be used the following factors are to be considered:

- **The materials of which the bags are made:** Bags can be made of jute, paper, sheet or woven plastic. Woven jute or plastic bags are very strong and often used for 50 kg. They have the advantage that they can be used several times. In spite of their higher initial price they are therefore usually cheaper to use than paper or sheet plastic bags. Disadvantages are costs of recollection, repair and the risk of contamination (Diseases). Paper and sheet plastic bags are used in sizes up to 50 kg. Paper bags are often made of several layers and may be lined with plastic to protect against moisture adsorption of the feed.
- **The shape of the bags:** Usual filling weights are 50 kg and 25 kg. Bags that are too thinly filled are less stable in piles and damage easily. Tied bags that are too long give difficulties in piling.
- **The method of closing:** Bags can be closed by tying with a string, by sewing or by heat-sealing.

Weighing and bag filling

For delivery of feed in bags there are two methods of weighing:

- Net-weighing, where the weighing takes place before bag filling
- Gross-weighing, where the material is weighed in the bag during bag filling

A net-weighing unit consists of:

- A feeding device
- A weighing bin
- A discharge hopper

Gross weighing can be done with:

- Platform scales under a filling spout
- Gross-weighing units.

Bag closing

Closing of bags after weighing and filling can be by:

- Tying with a string.
- Sewing.
- Heat sealing

Bulk delivery

Bulk delivery includes weighing and bulk loading at the feedmill and subsequent unloading of the bulk vehicle at the farms.

Advantages:

- Lower labour requirements
- Higher capacity in loading and unloading

- Lower storage space requirements
- No packaging required

Disadvantages:

- Higher investments in storage facilities are required
- Specialized transport trucks may be necessary
- Unloading requires energy supply
- Farms must be equipped with bulk storage facilities

Weighing and loading

An installation for bulk weighing and loading consists of:

- Bulk storage bins for finished products equipped with a mechanism for dosing into a scale or vehicle such as valve, grid valve or screw feeder
- A sieving machine to separate dust from pellets (only if pellets are produced)
- A weighing system for net weighing or gross-weighing of the product loaded into the vehicle

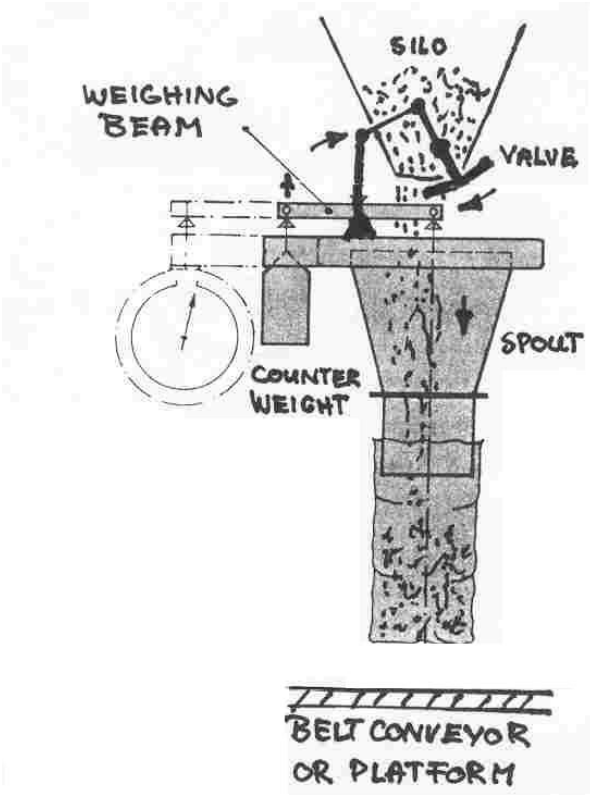
Types of vehicles

For bulk transport there are various types of trucks or trailers that may be used. The choice of the most suitable vehicle depends on such factors as:

- Transport volume required
- Size of charges to be delivered
- Method of unloading the vehicle at the farm
- Availability and cost of labour
- Required investment

Bulk trucks may be:

- Box trucks.
- Hopper bin trucks
- Tank trucks



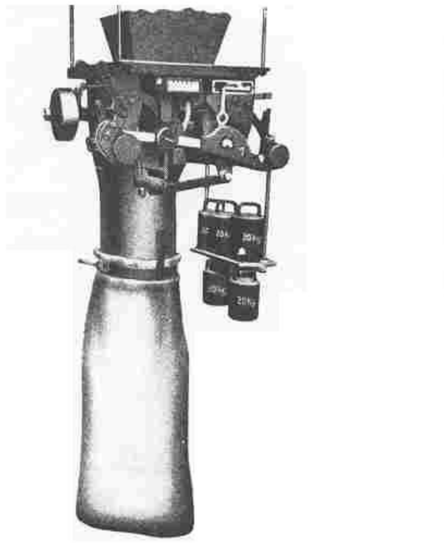
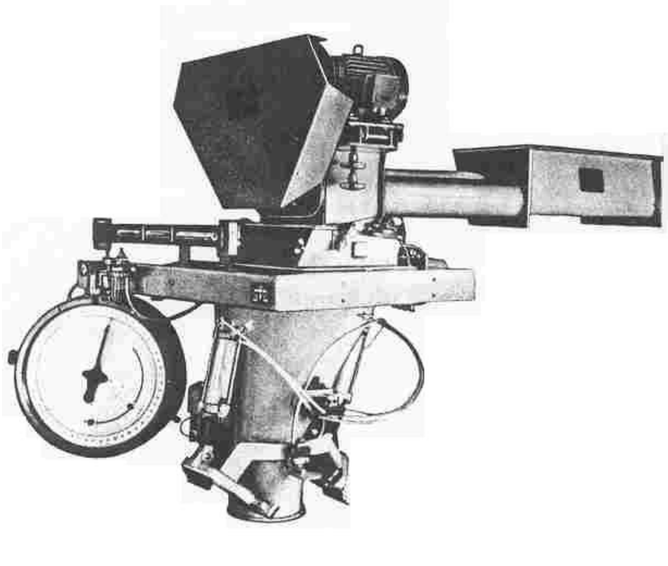
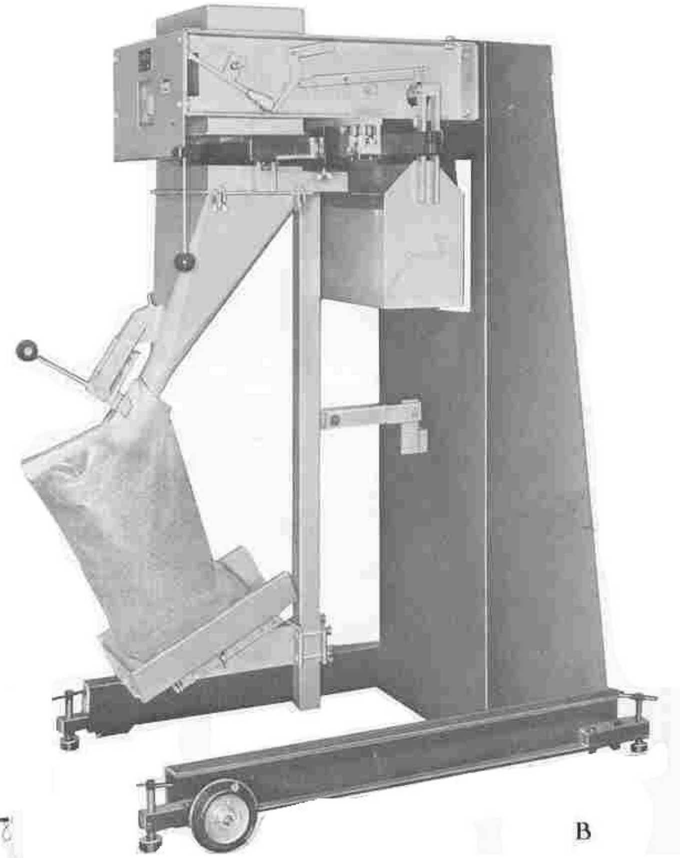


Figure 61: Gross-weighing units.



A

Figure 62: Bag filling and closing units.



B

C

Experiment 08
Formulation of Poultry Ration by Step Method

Introduction

It is essential in formulating poultry rations to distinguish clearly between nutrient requirements and nutrient allowance. The requirement of an animal for a given nutrient is the minimum quantity of that nutrient, when all other nutrients are supplied in a adequate quantity that will maintain normal growth and reproduction and at the same time prevent the development of symptoms of nutrition deficiency. When defined in this way the requirement for a given nutrient is the same as the "minimum requirement" for that nutrient. The allowance of a given nutrient is that quantity of the nutrient that is given to the animal. Actual poultry rations must contain great quantities of certain of these nutrients for the following reasons:

1. Feed intake and with it nutrient intake, depends primarily on the energy content of the ration. The higher the energy content of a ration, the less feed is consumed. Therefore high energy rations have to contain more protein, vitamins and minerals that low energy rations.
2. Feed intake is affected by environmental temperature. It has been shown the requirements of the vitamin thiamine of calcium and possibly of protein and ascorbic acid, are greaten at high that at low temperature. It is likely that the requirements of other nutrients are also affected by environmental temperatures.
3. Feed ingredients vary in their composition depending on origin growing and harvesting conditions processing length of storage etc.
4. Vitamins are partly lost if the feed or its ingredients are stored for any length of time, this loss is particularly rapid at high temperature and in the presence of certain minerals. In earlier reports suggestions were given for nutrient allowances instead of the requirements were given for nutrient allowances instead of the requirements. These allowance included margins of safety of 65% for vitamin A, 50% for vitamin D and 20% for most of the other vitamins.

How to formulate a ration?

Nutrient levels

Determine the nutrient levels of the feed to be composed:

- a range for the M. Energy level (maximum – optimum – minimum)
- A minimum percentage of crude protein to be reached
- a minimum percentage of methionine and lysine to be reached
- a minimum percentage of methionine + cystine to be reached
- a maximum percentage of crude fat to be considered
- a maximum percentage of crude fibre to be considered
- a maximum percentage for the calcium to be reached
- It applicable a minimum percentage for phosphorus to be reached

Feed formulation step by step

For high ca-feeds (layer, parent stock) start with step 1.

All other feeds start with step 2.

Step 1: Take 3% of an ingredient with more than 20% Ca.

Step 2: Include the vitamin/trace-element pre-mix and if that is not present in the premix common salt.

Step 3: Include any ingredient of which you want to have a minimum percentage in the ration.

Step 4: Include 30% of those ingredients which have an energy value higher than the required level of the ration you want to prepare (less than 30% if you included an energy rich ingredient in step 3). Take those which have the lowest "energy-price" but not more than a safe maximum for each ingredient.

Step 5: Use protein-suppliers to bring the feed to 50% use those protein-resource that contain more protein than you need in the feed. Choose those with the lowest "protein rice" but not more than a safe maximum for each ingredient.

Step 6: Add the "percentage" the energy values, the quantities of the various nutrients and compare this sub-total of 50% with the requirements. Select and add 10% of an ingredient "Cheaply" providing the nutrient (s) you lack most and evaluate now the 60% with requirements. Add another 10% and continue to do so until you reach 90%. Avoid exceeding maximum inclusion rates.

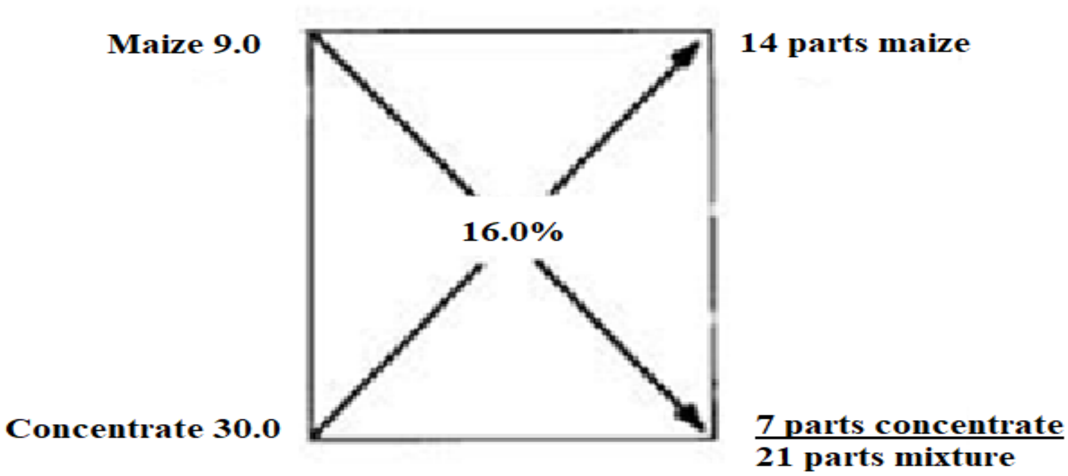
Step 7: At this point evaluate "what is still missing"? Possibly you need additional calcium or phosphorus sources. Add them and after that finish the feed by filling up to 100%. The use of the "Pearson square" might prove useful here.

Pearson's Square

Mr. Pearson was an American scientist who developed a method two combine 2 (never more than two) materials with different concentrations to obtain a mixture with exactly the concentration to be obtained.

Suppose maize (9% CP) and a concentrate (30% CP) are available. How much of each should be mixed in order to obtain a feed with a CP content of 16%. Use "Pearson Square" method (also called "Dairymen's square" or envelope method").

Answer:



mix 14 parts maize with 7 parts concentrate and the mixture contains 16% CP.

The quantities expressed in percentage are:

$$\text{Maize } \frac{14}{21} \times 100 = 66.7\%$$

$$\text{Concentrate } \frac{7}{21} \times 100 = 33.3\%$$

Exercise: Suppose we have available are: Soybean meal) 2100 kcal ME) and maize (3340 kcal ME). How many kilograms of soybean and maize should be mixed to obtain 100kg of a mixture with an energy content of 2600 kcal ME?

Formulation ration for broiler parent stock with the following ingredients by step by step method:

Ingredient	Price per kg	Min inclusion	Max inclusion
Limestone	5	3	10
Maize	23		70
Mustard oilcake	22		10
Soybean meal	34		35
Salt	10	0.2	0.4
Dicalcium phosphate	20		2.5
Cassava meal 73%	30		20
Rice bran	25		15
Fish meal	45		5
Premix BPS	100	1	1

Nutritive value of the premix BPS

Me	CP	lys	meth	M+C	Fibre	EE	Ca	P	inclusion rate
541	6.8	0.17	0.07	0.16	2	1.1	10.48	0.28	1%

Objective: Formulate a least cost broiler parent stock feed according to the requirements

Sl. No	Ingredients	Amount kg	ME Kcal	CP%	Tk/kg	Total cost
Step 1	Limestone	3	-	-	5/-	15/-
Step 2	Premix	1	5.41	0.068	100/-	100/-
	Salt	0.4	-	-	20/-	8/-
Step 3	Maize	10	334.0	0.87	23/-	230/-
Step 4	Maize	15.6	530.4	1.36	23/-	358.8/-
Step 5	Soybean meal	20	424.0	8.6	34/-	680/-
Step 6	Maize	10	334.0	0.87	23/-	230/-
	Maize	10	334.0	0.87	23/-	230/-
	Maize	10	334.0	0.87	23/-	230/-
	Rice bran	10	1.33	0.33	25/-	250/-
Step 7	Fish meal	3.12	103.5	1.56	45/-	140/-
	maize	6.88	229.79	0.60	23/-	158.24/-
	Total	**100 kg**	**2849.10**	**17**		**2630.44/-**

Feed cost per kg feed = 26.30/-

Experiment 09
Field trip commercial poultry farm and mills in Bangladesh

Experiment 10
Survey of feed market