Technological improvements in feedmills in Italy. Current status and tendencies

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Technological improvements in feedmills in Italy Current status and tendencies

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SUMMARY - A description of the main technological improvements in feed mills in Italy is given, with observations deriving from published information on feed manufacturing technology and from direct knowledge of the authors. Feed producers who do not invest in technological improvements are considered unable to survive on the market. A word of caution is expressed about the tendency of some feed producers to perform in-house tests on "superconditioners", which should preferably be tested by experts at experimental facilities.

Key words: Feed manufacturing technology, reception of ingredients, proportioning systems, grinding, mixing, conditioning, pelleting, extruders, expanders.

RESUME - *"Améliorations technologiques dans les fabriques d'aliments pour bétail en Italie. Etat actuel et tendances". Cet article présente une description des principaux progrès technologiques dans les usines d'aliments pour bétail en Italie, avec des observations provenant d'informations publiées en ce qui concerne la technologie de fabrication des aliments pour bétail, et découlant également de la connaissance directe des auteurs. Les fabricants d'aliments bétail qui n'investissent pas dans des innovations technologiques sont considérés comme étant incapables de survivre sur le marché. L'attention est attirée sur les dangers que présente la tendance de certains fabricants d'aliments bétail d'effectuer des tests maison sur des "superconditioners" ; il serait préférable que les tests soient réalisés par des experts dans des installations d'expérimentation.*

Mots-clés : *Technologie de fabrication d'aliments pour bétail, réception d'ingrédients, systèmes de proportion, mouture, mébuge, conditionnement, granulation, "extruders", "expanders".*

Introduction

The production of commercial feeds in Italy takes place in feedmills which generally utilise the "batch" system and can be categorised into different groups as follows:

(i) New plants with technologically-advanced processing, whether existing at the initial stage orimplemented in the course of time.

(ii) Relatively "old" feedmills which have undergone refitting or laid down a modernization plan.

(iii) Twenty-year-old plants expected to be able to produce good quality feeds without investment in new equipment.

Group 1 and especially group 2 deserve our attention. The majority of the mills pertaining to group three will not survive on the market.

We will focus on two main subjects:

(i) Which sections in the production line are submitted to technological improvement - and why.

(ii) Which solution is generally preferred by the Italian feed producers we have taken as examples (no names will be mentioned) whenever there exist different solutions in order to achieve a given technological benefit.

The information we provide on current status and trends in feed mills in Italy is based both on our direct awareness and on personal communications from various sources.

In the first part of this paper the "usual" feedmill, including both the pre-grinding and post-grinding systems, will be examined section by section. As a certain number of expanders have been connected to existing pelleting machines, expanders are included in this part.

As the subject of extrusion will be covered by an eminent speaker in the course of this Conference, our treatment of extrusion systems in the second part will be brief. A few examples of expanders producing feed for fish species are also mentioned.

Part 1

Receiving and storing dry ingredients in bulk

The current status of the receiving department is rather unsatisfactory in most cases, considering both "number" and "shape" of available bin hoppers provided for raw material in pre-grinding plants, or both the storage and batch-dosing of dry ingredients in the prevailing situation of post-grinding type mills.

Number of bin hoppers

The ever increasing number of NIRS (Near Infrared Reflectance Systems) placed at the receiving point in many feedmills provides very rapid information on key analytical characteristics (i.e. starch, protein, fibre, etc.) of incoming loads of raw materials. As the characteristics for a given raw material differ from one load to another, by using the NIR technique these loads may be physically separated by storage into different bins according to the quality divergence from the mean previously laid down by contract. This separation is feasible only when an adequate number of bin hoppers are available.

Unfortunately, only few feedmills in Italy possess a surplus of bin hoppers and so may accomplish physical separation of different series of loads of the same feed ingredient.

Shape of the bin hopper

Another important characteristic is the "shape" of all the bins "hanging over" or in any possible way "discharging into" metering hopper scales. This shape should be such that it:

(i) Avoids the occurrence of "bridging" of ingredients, especially those in meal form, without using vibrators or hammers.

(ii) Ensures a "first in - first out" flow of the stored dry ingredient, either in meal form or in pellets.

Unfortunately, many mills in Italy, particularly the "old" ones but also a certain number of those designed and built more recently, are equipped with bins of the "funnel flow" type. From a bin of this type, the different loads of the stored ingredient do not flow through the extracting-dosing device according to the first in - first out principle, but tend to follow a preferential path, approximately at the centre of the bin. This leads to stagnation of residues adhering to the internal surface of the bin wall. Furthermore, it offers the following disadvantages:

(i) Causes bridging, which interrupts the flow of ingredients and consequently blocks the automatic proportioning system.

(ii) Makes it impossible to keep the uniformity of the compound feeds at the desired level, given the inconsistency of the chemical analysis between different loads of the same ingredient stored in one bin.

(iii) Results in the occurrence of mould and finally the development of mycotoxins, the most dangerous consequence.

Some Italian feed producers are now expanding their receiving facilities by increasing the number of bin hoppers. Others are replacing their old "funnel flow" bin hoppers, in order to ensure a uniform first in - first out flow of each ingredient and to avoid the problems connected with bridging. Stainless steel is used for new bins, which in some cases are equipped with air guns. Bin hopper discharge devices are as long as the bin diameter itself and chain conveyors equipped with plastic blades ensure that both the chain and plastic coating material on the auger internal surface are kept clean.

Automated on-line NIRS (Audet, 1993)

Fully automatic on-line NIR systems are now operational in a small number of feedmills in Europe (Gill, 1995). NIR's may also be used downstream for on-line control of drying and cooling of products. As far as we are aware, no examples of this kind exist today in Italy.

Proportioning systems

Macro-proportioning

It would be superfluous to describe the advantages of the well known proportioning sliding gate system existing in all the West European countries, including Spain and Italy, where this proportioning system has been in use for more than two decades, having replaced the screw conveyor for each single ingredient. The proportioning sliding gate system does not seem to be susceptible of important innovations in the near future.

Micro-proportioning

Microingredients in animal feeds are components incorporated at inclusion levels below 500 ppm. The use of a good automated microproportioning system ensures that weighing errors do not exceed 0.04%.

The inclusion of microingredients directly into the main mixer, with or without prior premixing with a carrier, was the object of studies by scientists at the Kansas State University. The authors observed that the coefficients of variation among batches of feed did not differ significantly when microingredients were added as such or diluted in a carrier (Tables 1 and 2 in McEllhiney and Tangprasertchai, 1983).

The first automated microproportioning system was installed in northeastern Italy in 1986 at a twenty-five year old feedmill, as part of a refitting project. More recently, much more important and complex automated microproportioning systems have become operative: one in 1990 at a feedmill and, during the last three years, two at major plants producing vitamin and trace mineral premixes for the feed industry. These examples and both the 1992 and 1995 Victam-Europe Feed Trade Shows stimulated some of the major Italian feed producers to introduce automated microproportioning on-line systems in one or more of their feedmills.

A feedmill in which "proportioning of macroingredients, milling and pelleting operations, etc. are all automated is NOT FULLY automated" if manual operations have to be performed to include one or more ingredients in each batch of feed. If this assertion is taken for granted, we have good reason to adopt an automated microproportioning system connected to the line of production in our feedmill.

Table 1. Analytical results of drug assays in the final diet at different dilution levels (20 samples per treatment)

Dilution ratio	Analytical results†		Coefficient of variation (%)
	Mean†† (g t^{-1})	Range (%)	
Control	249	231-300	6.59
1:1	248	224-265	4.34
1:5	247	212-279	6.56
1:10	244	218-268	6.64
1:25	244	220-280	7.17
1:50	243	227-274	4.97

†Expected recovery = 264 g t^{-1}
††Treatment means did not differ significantly
Source: Adapted from McEllhiney (1985)

Table 2. Results of iron particle counts in the final diet at different dilution levels (20 samples per treatment)

Dilution ratio	Analytical results†		Coefficient of variation (%)
	Mean†† (count)	Range (count)	
Control	14.25	10-21	18.82
1:1	13.85	9-22	23.34
1:5	13.85	8-19	22.87
1:10	13.40	8-24	30.09
1:25	14.00	10-19	21.11
1:50	13.50	7-18	25.38

†Expected recovery = 12 counts per 50 g sample
††Treatment means did not differ significantly
Source: Adapted from McEllhiney (1985)
Note: Analysis by rotary detector from Microtracers™, Microtracers, Inc., San Francisco, CA

Grinding

Hammermills and sifters

For many years feed producers have been looking at the hammermill as the most suitable grinding instrument, considering its capacity to grind almost any feed ingredient, either separately or in combination with other ingredients. Hammermills are present around the world in feedmills of both the pre-grinding and post-grinding type. The main disadvantage to be confronted when using hammermills is the lack of uniformity in size of the ground particles exiting through the hammermill screen perforations. This type of grinding is particularly ill suited to the production of mash-type feeds.

Screening following grinding is usually recommended to ensure correct particle size. The concern for the best possible granulometric distribution of ground ingredients has determined the adoption of various types of sieving machines (sifters), which obtain definite granulometric profiles for each fraction of a ground ingredient, or combination of ingredients. However, in spite of the use of sifters, the relative amount of fine and extremely fine particles is still high in most cases. This has become more and more evident as the number of ingredients received as pellets - to be ground by impact with hammers in hammermills - has increased during the last few years. Excesses of fine particles represent a disadvantage, even when the amount of feeds produced in pelleted form prevails over mash-type feeds.

Large integrated companies concentrating their production on pelleted feeds generally use high-power hammermills, due to their simplicity, versatility and ease of maintenance. In post-grinding type feedmills, a sifter located upstream directs the grain and pellet fractions to the first series of hammermills, diverting towards the main mixer those ingredients in meal form which do not require milling. At the exit of the hammermill, the same sifter selects the "too coarse" fraction for regrinding, recirculating it to the same hammermill (2^{nd} screen with fine perforations) (Fig. 1). Where a second hammermill is placed downstream, it receives the coarse fraction from sifter 2 (Fig. 2). Such a system has been adopted by many Italian feed producers as one of the most important improvements in remodelling of "old" post-grinding type feedmills.

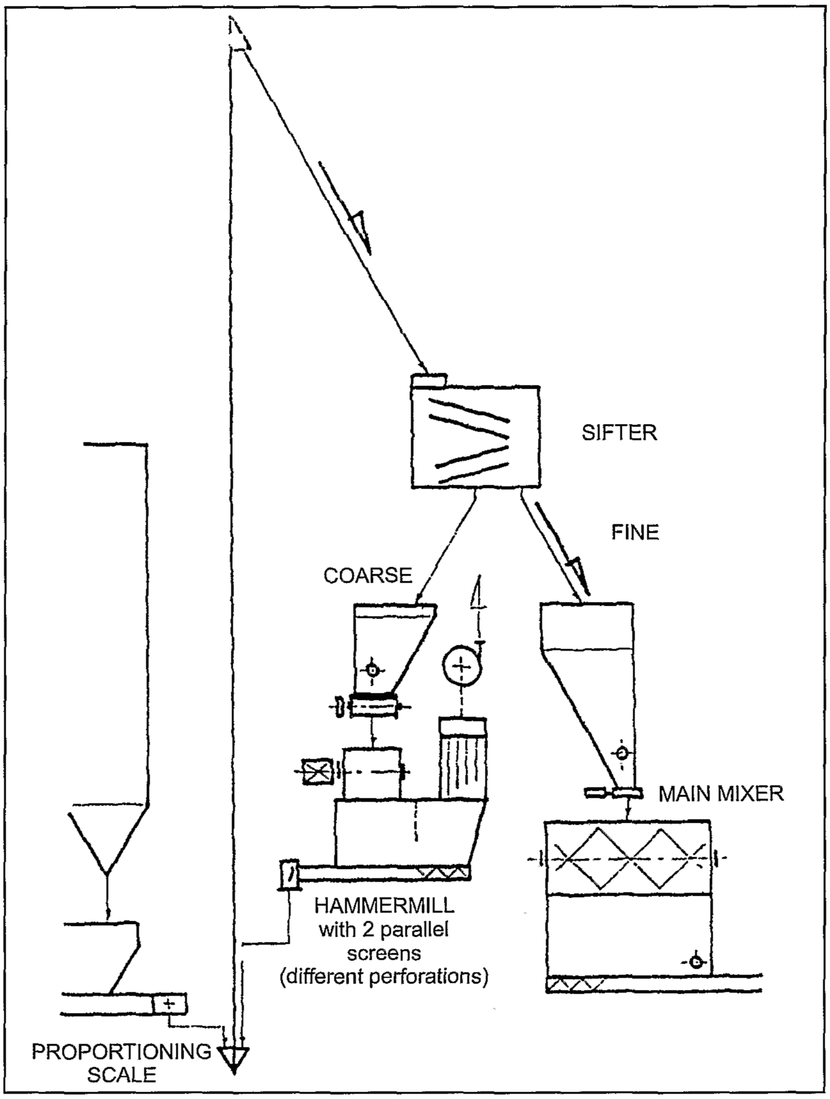

Fig. 1. One hammermill and one sifter.

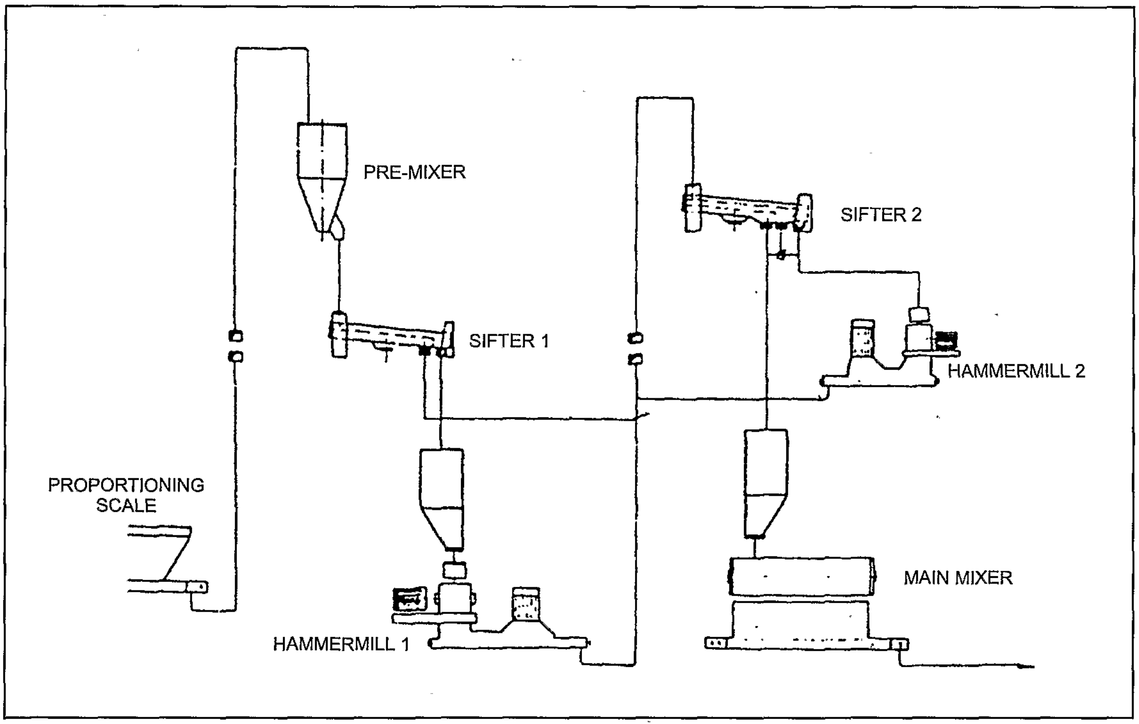

Fig. 2. Two hammermills and two sifters.

Vertical rotor hammermills

A narrow particle size spectrum can be achieved by using a vertical rotor hammermill, which could be either a recently improved version of an already existing machine or an entirely new model with a recirculating air system (Fig. 3).

At least one hammermill of the former type is now under test in a feedmill in Italy.

Rollermills

The new models of rollermills designed for the feed industry represent an alternative grinding system, particularly in feedmills where mash-type feeds are produced by using corn and wheat as basic ingredients. In the case of feedmills of the pre-grinding scheme, each different grain, as well as each ingredient in pelleted form is milled separately with a single-pair rollermill (Fig. 4). In the European context, where post-grinding feedmills prevail, mixtures of grains and pelleted ingredients can be milled with double-pair or triple-pair rollermills (Fig. 5). Gap adjustment of the roll pairs can be manual or automatic.

Some Italian feed producers adopt rollermills to integrate an existing hammermill grinding system, in order to produce good quality feeds in mash form, particularly for layers.

Mixing and mixers

Degree and uniformity of mixing

One general assumption is that feed mixers of any possible size, shape, design and configuration must achieve a coefficient of variation (CV) of 10% or less as the most important indicator of mixing ability and proper functioning (McEllhiney *et al.*, 1991).

If we take for granted that the manufacturer tested our mixer at the factory before shipping and installing it, we can assume that we have "received" a "good" mixer. Thereafter, as feed manufacturers, we should routinely test our mixer to ensure that it performs as expected or as it did when it was first installed. It is well known, for instance, that worn paddles or a worn external ribbon, respectively in a horizontal paddle or double-ribbon mixer, mean low-quality mix or at least unwanted prolongation of the mixing time.

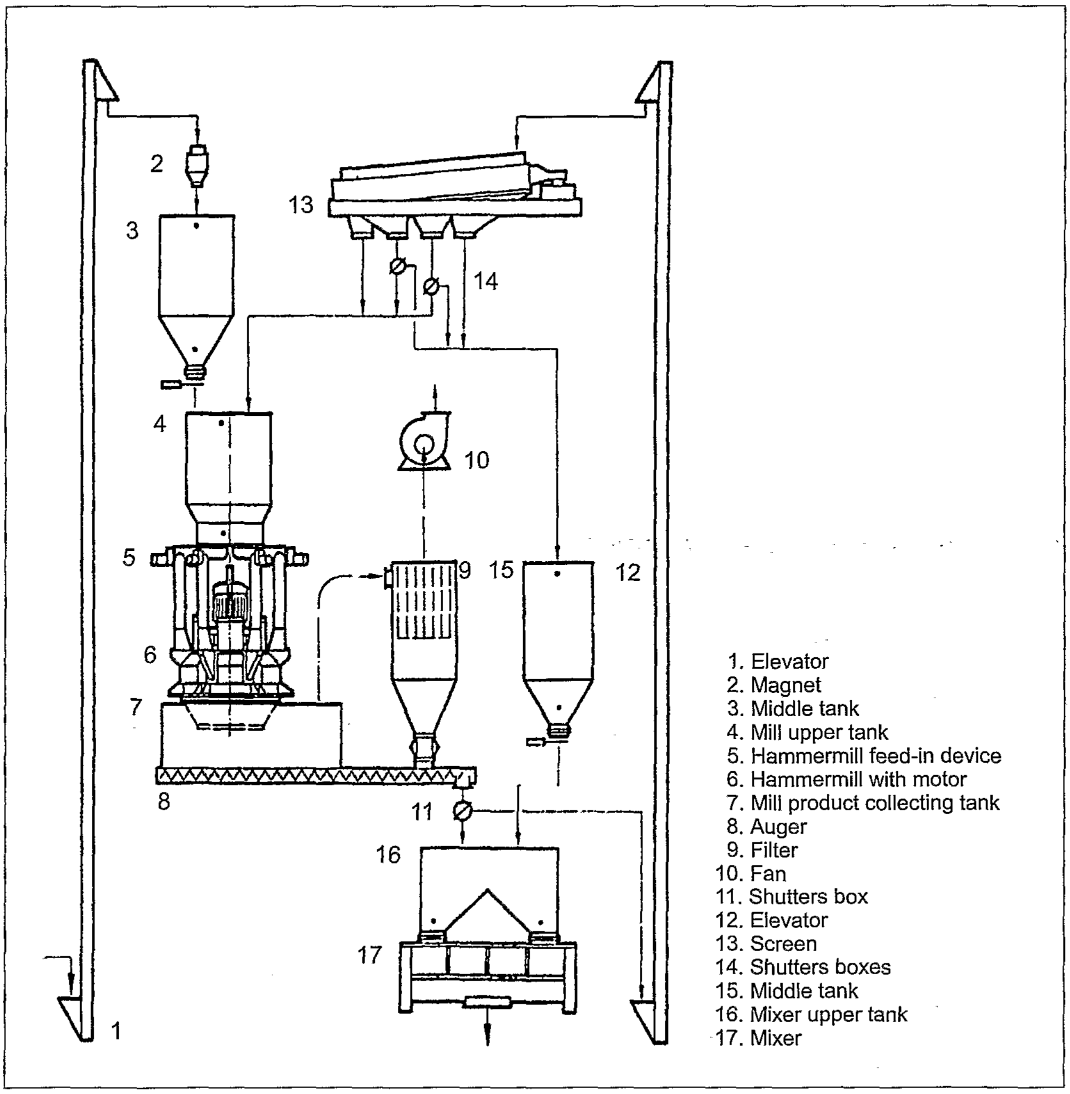

Fig. 3. Vertical rotor hammermill (Kahl).

Carry-over of additives and cross contamination

The next important issue regards "the possibility of quick total emptying of the mixer without residues, in connection with short conveying ways" (Heidenreich, 1995).

The discharge system of batch-type mixers existing in feedmills of the 2nd group ("old" mills) is generally of the slide-gate type, which does not ensure total emptying and absence of residues in subsequent batches of feed. This disadvantage is no longer acceptable and the most radical technological solution would be substitution of the mixer itself. The discharge device at the bottom of the mixer should be of the complete drop-bottom gate type and the conveying equipment downstream should be remodelled.

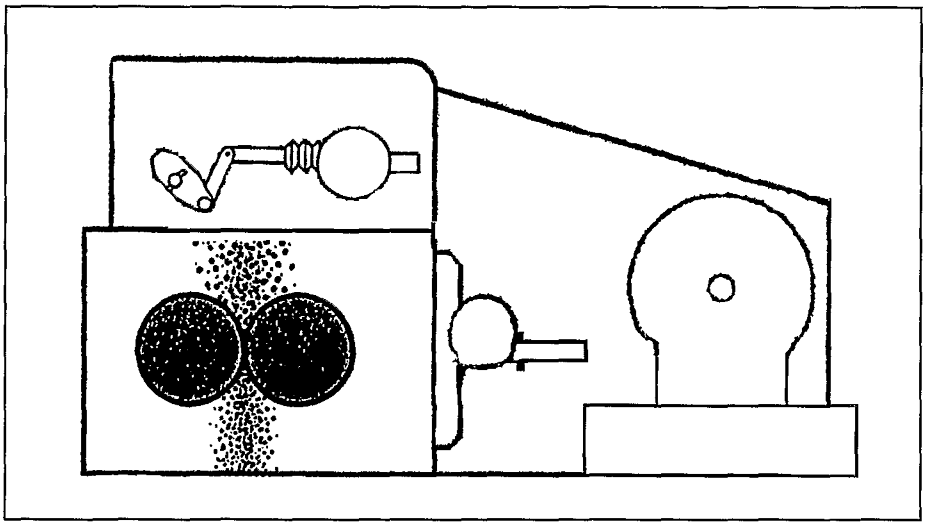

Fig. 4. Single pair rollermill.

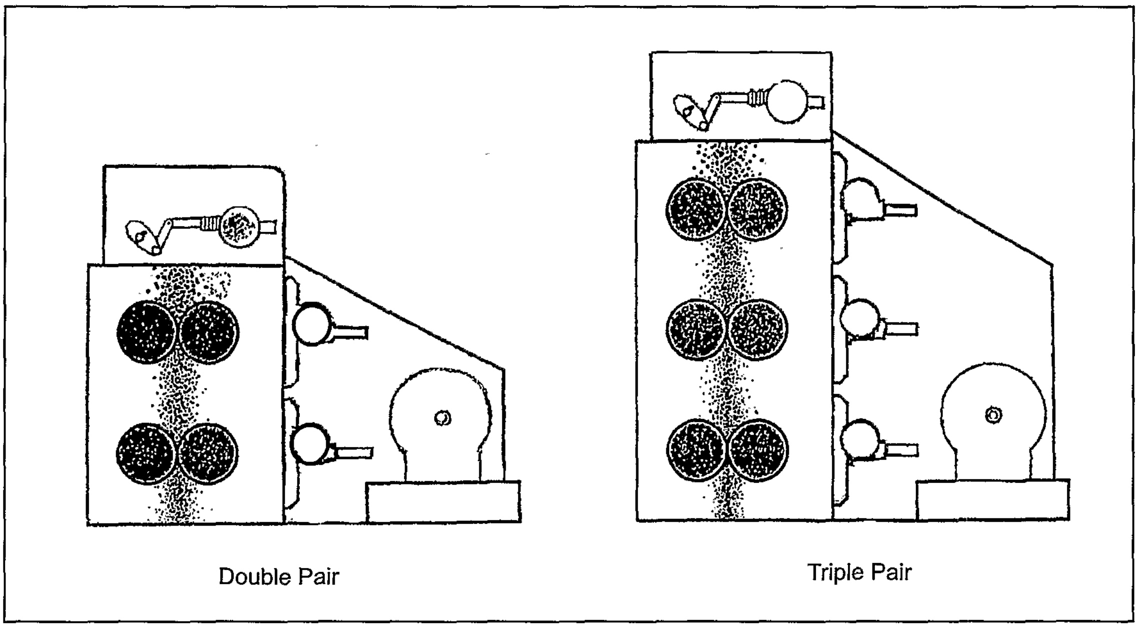

Fig. 5. Double pair and triple pair rollermills.

New mixers

Reducing the mixing time in a batch-system feedmill offers undeniable advantages. In a "traditional" feedmill, the proportioning, milling and conveying of a batch of feed to the mixer requires a certain number of minutes. So for instance, having a 3-minute mixing time mixer replaced by a twin-shaft paddle (TSP) mixer, which would require only 1 minute to get a good quality mix, could be advantageous if the proportioning operation could be accomplished by an adequate number of scales working in parallel mode. An example of how different types of mixers can accomplish their function according to specific mixing times is given by Heidenreich (1995) (Fig. 6).

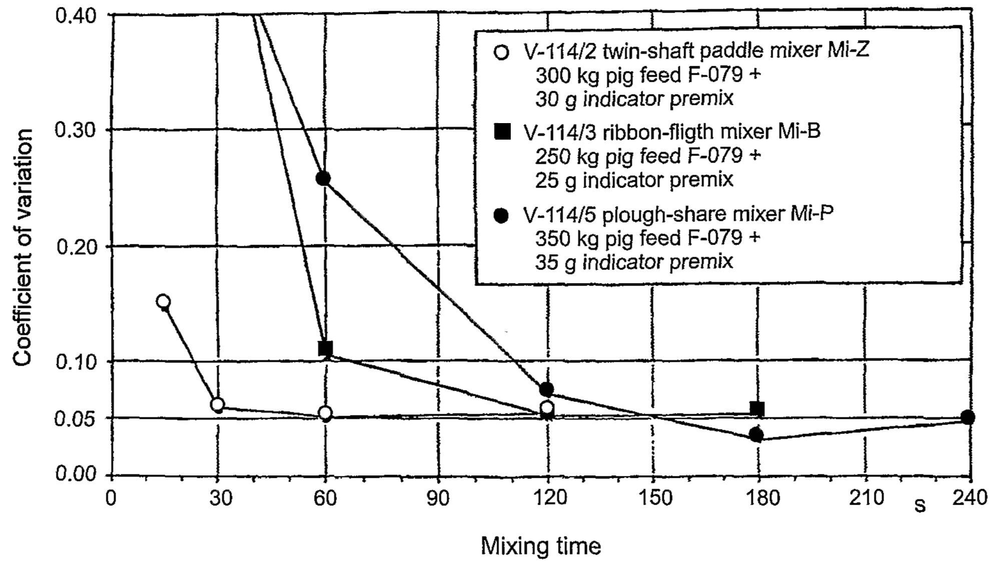

Fig. 6. Mixture quality curves for pig feed F-079 and different types of mixers. (Forschungsinstitut Futtermitteltechnik IFF)

Inclusion of fats and oils

It is advisable to limit the inclusion of fats in the mixer in order to avoid a reduction of the pellet quality, usually referred to as "durability" (resistance to abrasion and breakage) (Behnke, 1994).

The maximum level of fat to be included in the mixer is around 3-4% of the batch being mixed. When the rate of inclusion of fats and oils as a total exceeds such a maximum, a further addition can be accomplished by various systems that we will examine later (see Adding fat after pelleting).

Conditioning

Short term conditioning

Conditioning feeds in meal form by injecting steam into a "standard" conditioner, prior to pelleting, has been the rule in the feed industry for decades. The retention time of the meal in a standard conditioner can range from 5 to 15 seconds (Behnke, 1994). Therefore, we refer to it as short term conditioning. In most cases, this kind of treatment is not considered sufficient any longer, as far as duration and/or intensity are concerned, in consideration of two main needs: (i) inclusion of high amounts of liquids, particularly molasses; (ii) hygienization of feeds.

Long term conditioning

According to Behnke, long term conditioners can be of several design types, operate either vertically or horizontally, and be of a single pass or multiple pass configuration. The size, configuration, rotor design and operational speed are such that retention time is extended to 1- 5 minutes. The purpose is to increase the time of exposure so that the moisture and heat can penetrate the very centre of each particle (Behnke, 1994).

The first alternative to short term conditioning was the ripening kettle, or ripener (Fig. 7). The kettle has been in use for years in some Italian feedmills, in order to: (i) ensure a longer duration of treatment of high-fibre and high-molasses feeds or; (ii) inactivate anti-nutritive factors (ANFF) in legume seeds, especially full-fat soya beans (hydrothermal treatment).

Hygienization of feeds was not a primary concern when ripening kettles were first installed in some Italian feedmills about 10-15 years ago.

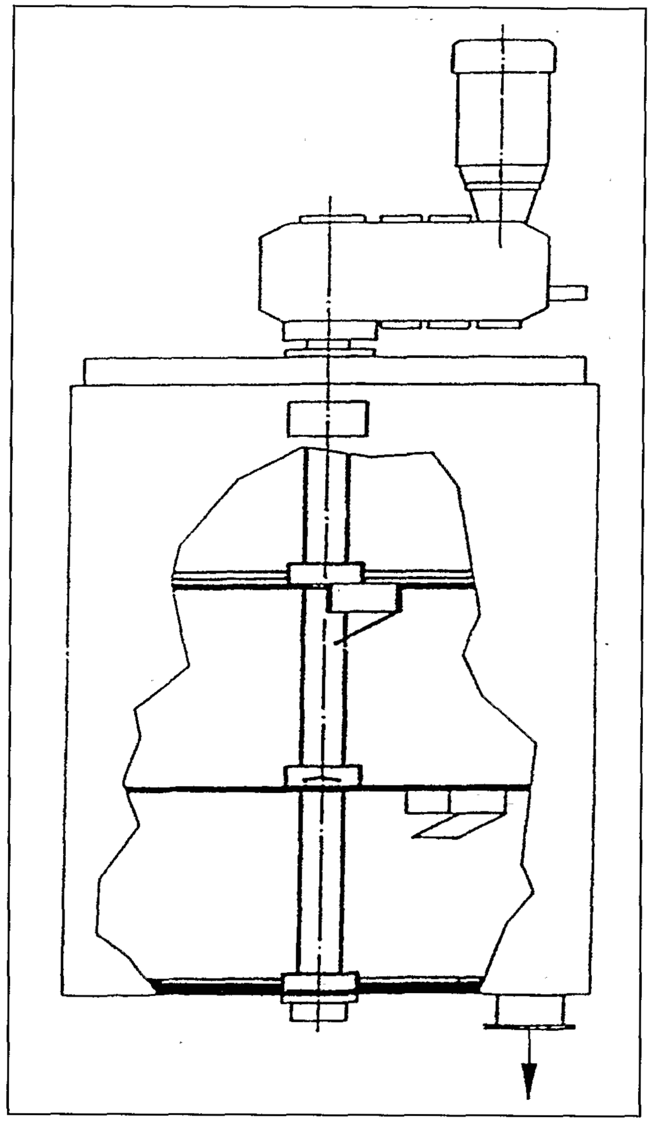

Fig. 7. Rippening kettle.

Hygienization of feeds

Concerning the topic of control of *Salmonella* and other pathogens in feeds, the reader is invited to check the list of references (Garland, 1993; Beumer, 1996).

Beumer (1996) has recently presented the paper, not yet published, "Quality and safety in the feed industry. Control of *Salmonella* and other pathogens in feed" at the 4th International Feed Production Conference in Piacenza, Italy. As options proposed for the elimination of *Salmonella* and other pathogens, this author reports a list of treatments (personal communication), as follows:

- Anaerobic Pasteurizing Conditioning (APC).
- High Temperature Short Term (HTST) or Expander.
- Hydro Friction Conditioner (HFC) or Boa Compacto.
- Scott mixer.
- Sterilisation by Increased Retention and Temperature (SIRT).
- Conditioning kettle (ripener).
- Long term conditioning followed by pelleting.

A description of all these different treatments would not be acceptable in this paper, which has to be kept relatively short. We will examine the current status and trends in Italy on the systems mentioned in the list:

(i) APC: No operative systems existing in feedmills. A project is under way at a broiler breeder farm, for a batch-type machine.

(ii) HTST: At least No.12 expanders installed:

- 5 for poultry feeds (broiler, meat turkey, broiler breeder feeds).
- 4 for ruminant and swine feeds (high-molasses in some cases).
- 2 for fish feeds.
- 1 for various kinds of feeds.

Note: Hygienization "not" the only goal. Other advantages taken into consideration by users.

(iii) HFC: none

(iv) Scott mixer: none

(v) SIRT: none

(vi) Conditioning kettle: (status and tendencies), see above, long-term conditioning.

(vii) Long term conditioning followed by pelleting: The tendency to replace short term (standard) conditioners is more and more evident today. Their main goals are extended retention time and higher temperature (see the following point).

Superconditioning

The efforts to minimise the risk of bacterial contamination in the FEED TO FOOD CHAIN have promoted a number of attempts, by manufacturers of equipment in many countries including Italy, to build and market various types of "superconditioners". At the conference mentioned above, Beumer stated: "If processes for elimination are applied, their effectivity must be demonstrated, using the Enterobacteriaceae present as an indicator organism" (Beumer, 1996). The potential of new superconditioners has to be investigated with care. A certain number of feed producers in Italy are now testing superconditioners as prototypes and trying to understand whether they can be proven as reliable and cost effective.

Pelleting

The operation of pelleting animal feeds requires manual or automatic adjustment of the flow rate of both the meal which has to be conditioned and the steam being injected into the meal. In automatically driven pelleting machines, such adjustments of meal and steam flow are constantly interrelated, according to a preset value of T°, quantity of mash feed and the Amp reading of the motor. There exists an increasing number of relatively simple pellet mill automations, capable of being developed into more complex systems. These include injection of molasses into the conditioning chamber and spraying of fat on to the pellets leaving the die.

Automatic roll gap adjustment

Automatic electric or hydraulic roll adjustment devices are available to set roll-die gaps. Such devices allow for remote continuous adjustment of the roll gap even during operation of the pellet mill. Some controllers can set roll gap to a pre-determined point according to the formula being pelleted (McEllhiney *et al.*, 1994).

As far as further automation of the pellet press goes, more than 300 remote roll adjustment systems are running in Europe today. About 20 such systems are present in Italian feed mills, more than 50% of which were designed and constructed in Italy.

"Few commercial feed manufacturers in northern Europe would consider installing a new pellet press without the option of automatic roll gap adjustment" (Gill, 1994).

Adding fat after pelleting

Further additions of fat - exceeding the maximum "tolerable" amount included in the main mixer - can take place after pelleting. Two basic systems have been in use for years worldwide in order to add fat post the press:

(i) Fat-spraying at the die onto hot pellets.

(ii) Fat-coating in a rotating drum coater, through which pellets slowly progress after having being sprayed with fat.

These systems still have a preeminent role in the feed industry in Italy. A relatively new system is represented by the Tatham Forberg mixer, a version of the twin-shaft paddle (TSP) Forberg mixer further developed as a fully automated "oil coater". At least two such machines were installed in Italy in 1995, following the remarkable sales performance obtained by this piece of equipment in the United Kingdom.

Drying/cooling of pellets

Counterflow coolers

Old-style horizontal coolers are still working properly, but new installations are mainly of the "bunker" type (at times multi-tiered "Simon-like" type). These coolers are easier to operate and clean, cheaper to buy and possess higher cooling efficiency.

The number of counterflow coolers or "bunker coolers" installed in Italian feedmills is steadily increasing. More and more counterflow machines are replacing vertical cross-flow coolers.

Part 2

Extruders

Before the advent and wide use of extruded petfoods and extruded feeds for fish, extruders were used in the feed business in Italy in order to submit oilseeds to heat treatment, particularly full fat soya beans. Such installations are still used mainly by traders of feed ingredients, but also by producers of complete feeds. Many of these extruders came from other industrial sectors and were adapted to this new function with varying degrees of efficacy.

The extruders of today are conceived to obtain consistent rates of production with reduced costs (reduction of wear) and can be automated. Some important aspects of the extrusion process will be described by an eminent speaker in the course of this Conference. We only mention the fact that both twin-screw and single-screw extruders are used to produce petfoods and fish feeds in Italy.

Expanders

As reported above (see Part 1, Hygienisation of feeds), two expanders were installed in Italy, one in 1994 and the other in 1995, by two different producers of commercial fish feeds. These feed producers do not have extruders installed in their feedmills.

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