OPTIMISATION OF PRODUCTION FACILITIES WITH REFERENCE TO QUALITY ASPECTS

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What is quality?

Quality is a ubiquitous term that is used in numerous contexts today. It often describes aspirations or intangible requirements. An exact definition of quality standards requires measurable criteria. But these quality parameters in the scientific sense, which can be determined in a reproducible manner and with accuracy, are often not sufficient to describe complex quality requirements. Especially in the case of emotionally charged products such as food, quality parameters must be extended by adding subjective criteria. The weighting and direction of these subjective criteria is often partially influenced by political considerations.

Which quality requirements confront a breeding operation?

The quality requirements for a breeding operation result from two factors: firstly the fact that planned breeding work is based on understanding and utilising biological processes and that these processes must take place under standardised environmental conditions, and secondly the fact that successful breeding activities require the extensive keeping of animals. We must not forget that the objective of breeding work is the production of high quality food in sufficient quantity and that performance testing also yields products that are marketed as food.

Quality and animal husbandry

Quality in connection with animal husbandry can be viewed in two different ways:

- from the animals' perspective in terms of animal rights and animal welfare and
- from the perspective of the end product in terms of food safety and hygiene.

A breeding operation must consider both aspects, while also giving high priority to the objective of optimising breeding progress in performance and quality characteristics.

Quality and food

Food quality is judged by numerous criteria. They include

- product safety,
- nutritional value,
- eating quality,
- wholesomeness and
- the way food is produced from an animal welfare perspective.

The weighting of these parameters shifts over the years and decades in a continuous process, but can undergo dramatic changes in the short term when current trends or "scandals" cause concern. Because of the wide-ranging definition of quality, all operational resources used in the production of food must be subjected to the most thorough scrutiny in order to minimise deviations from set targets.

Quality requirements in a breeding operation

In addition to the requirements already stated, a breeding operation is subject to further demands and constraints. The production premises and resources used must at least meet the standards for food production. Deviations arise as a result of far more stringent hygiene requirements imposed by legal regulations and the position of the products at the beginning of the production chain (multiplication effect).

Quality requirements for the hatchery

The hatchery represents a bottleneck in the production chain. It is a collection point for hatching eggs and personnel, including visitors, and is the arrival and departure point for transport and packaging materials. As there is also an exchange of material from and to the hatching egg production sites, good hygiene management must be a top priority. In addition to this quality parameter, there are other criteria such as chick vitality, workstation design and compliance with animal welfare regulations.

Hatchery layout

The extensive movements of material and personnel from, to and within the hatchery make it essential that operational areas are defined and demarcated by their degree of hazard. In order to ensure good hygiene management, facilities must be in place for segregating personnel, strict access control and regulation of vehicular traffic and deliveries.

As regards hygiene hazards, the risk potential is relatively high at the point of egg reception and then declines during processing, grading and disinfection of the eggs for setting. From the point of transfer onwards the risk increases again, reaching a very high level during hatching and chick processing. A large build-up of dust and dirt during hatching and poorly hatched or unhatched chicks pose risks as the possibility cannot be ruled out that these materials may be contaminated with bacteria. Strict segregation of the hatching and chick processing zone from other operational areas of the hatchery is therefore essential for continuous hygiene management.

Selection of incubators

The selection of incubators is determined by the statistics relevant to the hatchery but also by chick quality all the way to arrival at the customer's farm. All machines must additionally meet basic requirements such as operational safety, hygiene control, a stable hatching climate, machine size appropriate to the quantity of eggs placed and control and recording of the main hatching parameters.

Hatching results for machines from different manufacturers normally show only small differences. This is not surprising since, with the exception of a few new designs, the technical concepts are very similar.

Table 1: Comparison of hatching results (Test 1)

Machine	1	2	3
1A Hatching rate %	83.1	83.0	79.9
Chick losses %	0.14	0.40	0.20

Machines 1 and 2 are very similar in their basic design, differing only in ventilation details and standard hatching programmes. Machine 3 on the other hand represents a new concept which dispenses with a fresh air supply altogether for the first few days of hatching and relies entirely on recirculated internal air. As was to be expected, there were no differences in the hatching results of machines 1 and 2 (Table 1). In machine 3 problems occurred with humidity control during hatching, resulting in a larger number of unhatched and second grade chicks. Losses in transit and during the first few weeks of life were negligible. Yet it became apparent that the chicks incubated in machine 2 were weaker on leaving the hatchery, resulting in greater losses after housing.

In order to extend the comparisons, a fourth machine was tested and compared with the best machine from the first test and the existing standard machines (Table 2).

Table 2: Comparison of hatching results (Test 2)

Machine	1	4	Standard
Hatching rate %	83.5	83.5	83.0
1A Hatching rate %	77.9	76.3	-
Chick losses %	3.45	4.25	6.46

While the overall hatching rate was identical for the two machines tested, machine 1 was clearly superior with regard to the number of 1A chicks hatched. The quality grading of the standard machines during routine operation was far less accurate so that this parameter could not be included. The differences in chick quality were also reflected in the numbers lost after housing, with considerably higher losses being recorded than in the first test because of the longer transport time. As was to be expected, the highest losses occurred among the chicks hatched in the standard machines because grading was less stringent.

Because of the different way in which the fresh air supply was handled in the first test, eggs were removed after 10 days incubation and examined for the presence of bacteria on the shell and in the egg. This was intended to show what effect a reduced air supply has on the microbiological quality (Table 3).

Table 3: Bacterial contamination (per cent eggs) after 10 days incubation

Machine	1	2	3
Shell %	73.3	76.7	83.3
Egg contents %	0.0	3.3	0.0

The percentage of surface-contaminated eggs indicates a clear correlation with the amount of fresh air supplied during the first phase of incubation. The complete absence of fresh air, as in machine 3, evidently causes an accumulation of bacteria on the egg shell, thus increasing the risk of cross-contamination in the incubator.

Implications for hatchery design

The design of a hatchery project must coordinate several different objectives. As well as fulfilling expectations for more efficient and hence more economical production, the quality of the chicks dispatched to the customer must be optimised. It has been shown that the benchmark is not the quality during grading of the chicks on the day of hatching, but on arrival at the farm and after the first few days of life. The design of the entire technology plays a part here because the scope for influencing what happens after hatching and in transit is negligible (Table 4).

Tabelle 4: Effect of feeding chicks during transport on initial mortality

Mortality % during	without Feed	with Feed
Transport	0.42	0.35
Day 1 - 7	3.2	2.8
Day 0 - 26	4.4	4.6

Finding an incubator that meets all the requirements to an equal extent is impossible. Evaluation of the systems has shown that modifying a proven technology can often provide more stable results than entirely new designs.

The potential of a completely redesigned hatchery lies therefore more in the opportunity for improving the layout of operational areas and optimising product flows from a hygiene perspective rather than the use of completely new technologies.

Quality requirements for feed supply

The quality requirements for feed are determined by the need to provide the correct diet, uniform feed quality and flock hygiene. Measures to achieve these objectives include careful selection of feed components to match the requirements of the birds concerned, depending on genetic type, husbandry system and age, restriction of the raw material range for hygiene reasons and implementation of hygiene measures during production and transport.

Feed quality problems

Deviations from the quality standard can occur as a result of

- non-conformance with specifications for certain nutrients,
- inhomogeneous dispersion or demixing of components,
- presence of foreign matter in the feed and
- carryover of undesirable components into the feed.

Non-conformance with specifications, other than mixing errors, is mainly caused by fluctuations in the nutrient content of raw materials. The risk of such deviations is greater the more batches of the same raw material from different sources are processed in the plant. For optimisation purposes standard values are usually adopted for feed ingredients, which do not take temporary deviations into account (Table 5).

Table 5: Feed analysis - Non-conformities in the energy content (samples collected over 1 year)

Feed	A	B
Target value (MJ/kg)	11.7	11.6
Mean value (MJ/kg)	11.7	11.7
Minimum value (MJ/kg)	11.2	10.6
Maximum value (MJ/kg)	12.2	12.3
Standard deviation	0.29	0.30

Although the means closely match the specifications, the extreme values show a wide range of variation with a standard deviation from the mean of about 2.5 % of the mean.

The situation is similar with regard to crude protein levels. Here, too, the mean closely matched the specification, but wide variations were recorded at the upper and lower end of the range. The average deviation from the mean was about twice as high as for energy (Table 6).

Table 6: Feed analysis - Non-conformities in the crude protein content (samples collected over 1 year)

Feed	A	B
Target value (%)	17.8	17.0
Mean value (%)	18.0	16.9
Minimum value (%)	16.3	15.7
Maximum value (%)	20.1	18.5
Standard deviation	0.97	0.79

While fluctuations in the energy and crude protein content are due to deviations in the nutrient concentrations of the components used from the values specified in the optimisation matrix, variations in mineral ingredients must be caused by other factors because supplemented minerals usually have a relatively constant composition (Table 7).

Table 7: Feed analysis - Non-conformities in the calcium content (samples collected over 1 year)

Feed	A	B
Target value (%)	3.9	3.8
Mean value (%)	3.8	3.7
Minimum value (%)	3.2	2.4
Maximum value (%)	5.2	5.3
Standard deviation	0.45	0.48

Note the very high standard deviation from the mean of about 12 % in the analytical data for calcium. The extreme values also show a wide divergence from the specification of almost 50 %. This high degree of variability can only be explained by demixing processes. The causal factor was probably the cooling after the heat treatment.

The figures do not take into account further segregation caused by transport and the pneumatic loading of the feed into silos. When added to further losses in homogeneity before the feed reached the animal, these factors indicate an extremely uneven dispersion of the supplemented calcium in the poultry house.

Carryover - not just a residue problem

In a compound feed plant where prophylactic or therapeutic substances are added to feed special caution is indicated in order to prevent carryover into other feed batches. If we assume that in feed manufacture an analytical result stating that a substance is “not detectable” is evidence of satisfactory production, it does not necessarily follow that this also implies absence of residues in food produced with this feed material (Table 8).

Table 8: Analytical differences in feed and eggs using Nicarbazin as an example

Analysed concentrations in eggs	5 - 15 µg/kg
Feed analysis	> 1 mg/kg = not detectable

Because of differences in the sensitivity of analytical systems in eggs and feed, the presence of Nicarbazin residues was detected in the eggs, whereas it was impossible to provide analytical evidence that the drug had been transferred to the affected flock through the feed. But as it could be shown that no Nicarbazin had been used throughout the life of the flock, the feed must have been responsible. This is even more probable in view of the fact that during the period when the residues occurred Nicarbazin had been mixed into other feed batches at the plant. Despite running several flushing batches, carryover obviously could not be prevented.

Carryover of undesirable substances into the egg is not only a problem when eggs are sold as food. When the hatchability of eggs from a particular flock suddenly declined by up to 50 %, carryover of coccidiostats (in this case Lasalocid) was suspected as the possible cause (Table 9).

Table 9: Analytical differences in feed and eggs using Lasalocid as an example

Analysed concentrations in eggs	0.31 mg/kg
Feed analysis	< 10 mg/kg = not detectable

The detection limit for Lasalocid is also far lower in eggs than in feed. The cause of the massive problems in hatchability would not have been identified if the hatched eggs had not been tested for Lasalocid residues. As was the case with Nicarbazin, the drug had been used at the plant in preceding batches. Once again carryover could not be prevented despite extensive precautions.

Feed hygiene

Increasing demands on the hygienic safety of food require special precautions in the use of all equipment, especially in breeding and multiplying operations. Monitoring of flocks for absence of specific disease agents shifts these precautions increasingly from treatment after an infection has occurred to prevention of the infection by isolating affected animals. Effective disease prevention requires that no relevant organisms are allowed to enter the animals' environment via the feed.

Need for extensive precautions

Feed production and distribution poses risks of bacterial contamination at several levels. The feed itself may contain microorganisms or pathogens can be carried with delivery vehicles from the feed mill and its surroundings into the animals' environment.

Feed hygiene measures must therefore consider not only the hygienic safety of the feed itself but also transport arrangements, feed manufacture and the location of the production site.

Negative test results of microbiological feed analyses do not provide the necessary security. The tested samples, weighing just a few grams, are by no means representative of the large volumes fed to flocks. It is also probable that any bacteria which may be present are not evenly dispersed but occur in clusters. A positive test result therefore either indicates a massive problem or is an accidental hit comparable to a lottery win.

It follows that negative tests for salmonella are suitable for assessing the quality of feed hygiene measures only, if at all, after a test contamination. More predictive are continuous, regular results of total microbial counts and the presence of Enterobacteriaceae, which can provide information about the effectiveness of hygiene measures in place of salmonella (Table 10).

Table 10: Results of microbiological feed controls over 1 year

Mean microbial count per gram	3,700
Minimum	100
Maximum	1,000,000
E. coli detected	26 %

Despite the heat treatment of the feed in the mill, a consistent microbiological quality could not be ensured. Recontaminations after the treatment and possibly the treatment process itself may have been responsible.

Any thermal treatment must be followed by a cooling process, which involves passing large volumes of air through the feed. If the cool air is not adequately filtered, bacteria are reintroduced into the feed. This is inevitable as a large build-up of dust occurs in the vicinity of feed mills, which is carried in the air. The attraction of feed mills to wild birds adds to the potential for microbial contamination of this dust.

Requirements for the decontamination process

Heating reduces microorganisms only to a certain extent. Feed must retain its biological quality after heating, which is why complete sterilisation is virtually impossible. The limitation in terms of potential combinations of temperature and exposure time therefore requires that each individual feed particle is exposed to the treatment. The higher the level of contamination of the raw materials, the greater are the demands on the reliability of the heating process itself. Continuous processes are usually unable to provide this level of security. If just a few contaminated particles leave the heating facility, the bacteria will inevitably multiply in the cooler as the feed passes through temperature ranges which favour bacterial growth. In extreme cases the feed may contain more undesirable microorganisms than before the decontamination process.

To achieve reliable decontamination, only process operating as batch system should therefore be considered, which are designed as a closed unit of heating and cooling facility and equipped with a sophisticated air filtering system.

Implications for the supply of feed to breeding flocks

Ever increasing requirements for feed quality in terms of absence of residues and high standards of hygiene demand, in addition to careful selection of raw materials, also structural measures in feed production and distribution. The feed must come from an environment with the lowest possible hazard potential and be subjected to effective decontamination measures. Safety can only come from the selected processes themselves, not from subsequent analytical tests with negative results. The complex processes of feed production and processing must be matched to the relevant quality requirements at the planning stage and then implemented in all technical details. The current consensus is that the scope for achieving this through modification of existing plants is limited.