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Keywords: Salmonella, Heat treatment, Pressing

Decontaminating poultry feed
Pilot workshop study of heat treatment techniques

1. Introduction

This program, financed by TECALIMAN's members, the ACTIA and the Pays de Loire region, has been implemented by TECALIMAN in partnership with the CNEVA in Ploufragan and the ENITIAA's Mathematics, Statistics and Computing Laboratory in Nantes.

The aim of the work is to determine the influence of steam treatment, pressing and deferred cooling of pellets on the level of salmonella contamination affecting a feed.

The technological factors activated are temperature and the duration of steam treatment. These factors are chosen as they are two factors that can be easily activated in the plant.

The biological criteria used to assess the influence of treatment conditions are:

- the percentage of 25g samples testing positive for salmonella.
- the percentage of 25g samples with colonies of bacteria other than salmonella, (colonies detected during the course of the salmonella isolation phase).
- the quantity of enterobacteria per gram of product

Three series of tests are conducted:

- Steam treatment, by load, of a poultry feed meal artificially contaminated with a salmonella strain characterised by an antibiotic resistance factor (Rifampicin).
- Steam treatment, by load, of a soybean press cake naturally contaminated with salmonella.
- Continuous steam treatment and pressing of a soybean press cake naturally contaminated with salmonella, with or without deferred cooling.

2. Equipment and methods

2.1. Test series no. 1: steam treatment, by load, of a feed artificially contaminated with salmonella

Natural contamination of a feed is generally very low and random. Under these conditions, it is hard to study the influence of treatment conditions on the level of contamination affecting the treated product.

To control the feed's initial level of contamination, an initial series of tests is conducted on feed batches contaminated artificially at a rate of 103 salmonella/g. These tests are carried out in two phases:

- The technique for artificially contaminating the feed is developed during the course of the first phase. (S. Cottin 1995).
- Batches of meal, intended for poultry feed, are artificially contaminated at a known rate during the course of the second phase. The feed is steam treated, in 15 kg loads, in an enclosed chamber. The technological factors examined are residence time (6 seconds - 29.4 minutes) and temperature (53 - 106°C). Tests are conducted in protected conditions in Ploufragan. The formula used is a finisher chicken feed with 4% fat.

2.2. Test series no. 2: steam treatment, by load, of a soybean press cake naturally contaminated with salmonella

There are two reasons for the decision to carry out these tests on products that are naturally contaminated :

- It is impossible to use artificially contaminated products to proceed with the remainder of the program, for safety reasons.
- There is a need to check that the treatment conditions applied to batches contaminated artificially are applicable to products contaminated naturally, in which salmonella strains that are more resistant to treatments could be present

The study comprises 4 tests, two temperature levels

(78°C and 87°C) and two treatment duration levels (60 and 180 seconds).
The treatment process used is the same as that used during the course of the previous study

2.3. Test series no. 3: continuous steam treatment combined with pressing, or not, of a soybean press cake naturally contaminated with salmonella

The aims of these tests are:

- to define the minimum conditions for continuous steam treatment to destroy the salmonella present in a naturally contaminated product,
- to assess the level of salmonella elimination when the meal passes through the pelleting press,
- to assess the level of salmonella elimination when the cooling of pellets is deferred by 5 minutes.

To achieve these aims, a naturally contaminated soybean press cake meal is subjected to different steam treatment conditions in a conditioner. The product is subsequently compacted in a pelleting press, then dried and cooled.
The technological factors examined are residence time (23 - 220 sec.), treatment temperature in the conditioner (51°C - 85°C), pressing and keeping pellets at their pelleting temperature (88°C) for 300 seconds before cooling.
Heating of the product in the conditioner is guaranteed by the direct injection of steam and by a double wall.
The meal is subsequently compacted into pellets with a diameter of 4 mm using an 11kW press. The unit's compression ratio is 15 and its linear speed is 7 m/s. The product's residence time in the unit is between 5.5 and 7.1 seconds.

3. Results

3.1. Test series no. 1: steam treatment, by load, of a feed artificially contaminated with salmonella

The average moisture content of products at the conditioner outlet is 18.1%.
The treatment conditions that are closest to the conventional conditions for preparing meals prior to pelleting (18 seconds at 73°C) do not enable salmonella to be eliminated (86.6% of samples test positive for salmonella).
Steam treatment is effective when its conditions are more intense; for example, 6 seconds at 106°C or 54 seconds at 87°C.

3.2. Test series no. 2: steam treatment, by load, of a soybean press cake naturally contaminated with salmonella

The moisture content of the meal at the conditioner outlet is between 13.3 and 15.6%. The quantity of water provided by steam, during the course of treatment, depends on the treatment conditions (temperature and treatment duration)
Prior to treatment, the soybean press cake is contaminated with salmonella. Contamination affects 78 to 87% of samples
After heat treatment at 78°C and whatever the residence time, none of the samples were found to be positive. The same applies to 87°C for 180 seconds.
The influence of treatment conditions on **bacteria other than salmonella** is very significant, hence when:

- at a temperature of approximately 78°C, the treatment time increases from 60 seconds to 180 seconds, the percentage of positive samples falls from 83% to 30% respectively.
- for a duration of 180 seconds, the treatment temperature rises from 79°C to 87°C, the percentage of positive samples falls from 30% to 3%.

3.3. Test series no. 3: steam treatment, combined with pressing, or not, of a soybean press cake naturally contaminated with salmonella

3.3.1. Continuous steam treatment

The distribution curves for the product's residence time in the conditioner reveal that this distribution is not completely uniform.
The moisture content of the meal following steam treatment is between 13.9 and 16.8%. It depends on the way the conditioner is operated (incorporation of steam, heating via a double wall).
Prior to heat treatment, 83 to 100% of the samples analysed were carriers of salmonella. The press cake's level of contamination with enterobacteria is close to 105 fcu/g.
The duration of steam treatment has no effect on **salmonella** and **enterobacteria** (23 sec/91 sec/220 sec), while the treatment temperature is revealed to have an influence for these bacteria.
Consequently:

- at 55°C, no temperature influence is observed for salmonella and enterobacteria populations.
- at 70°C (the usual treatment temperature for the conditioner), decontamination is almost non-existent. On average, 90% of samples remain contaminated with salmonella. The fall in the enterobacteria population is less than 0.5 Log.

- at 85°C, the elimination of salmonella is significant, but, on average, 3% of samples remain contaminated. Enterobacteria populations are found at a lower threshold than the detection limit (in this case, 2.3 Log).

Similar to previous tests (test series no. 2), the effect of treatment conditions and specifically the duration of treatment on **bacteria other than salmonella** can be detected. Consequently, following treatment at 85°C for a duration of 23 seconds, 67% of samples are positive. At this temperature, a treatment time of 100 seconds or more needs to be maintained for treatment to be significantly effective (7% of samples positive).

3.3.2. Pressing

There is a significant contribution of heat energy caused by friction in the unit. It causes a rise in the product temperature of 14 °C for steam treatment at 84°C and of 35°C for treatment at 55°C.

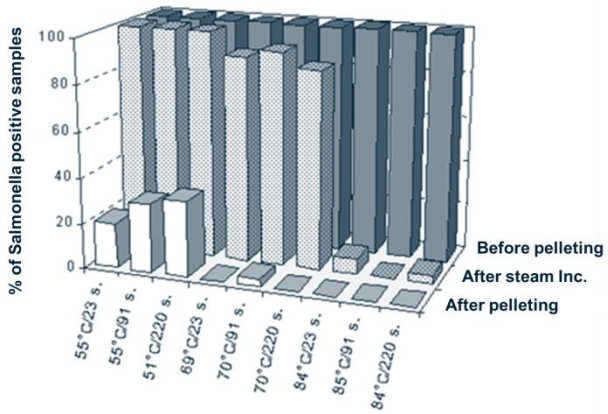

Figure 1: The influence of steam treatment and pressing

Percentage of samples testing positive for salmonella before and after treatment

The durability of pellets is 86.7% (Holmen method).

The effect of pressing on the level of salmonella and enterobacteria contamination affecting the product is similar. It can be detected when steam treatment temperatures are low. Consequently, following steam treatment at 55°C, the number of samples contaminated with **salmonella** falls from 100% at the conditioner outlet to 28% at the unit outlet, respectively.

Steam treatment temperatures of 70°C for 220 seconds, or 84°C for 23 seconds, are necessary to achieve complete elimination of salmonella during pelleting (Figure1).

The effect of pressing on **bacteria other than salmonella** is less significant than that observed previously for salmonella and enterobacteria. As a result, pressing of press cake treated at:

- 70°C, whatever the duration of treatment, enables the percentage of positive samples to be reduced from 100% to 30%.
- 85°C, for a treatment duration of 23 seconds, enables the percentage of positive samples to be reduced from 67% to 30%.

To eliminate a significant proportion of this group of bacteria, it is necessary to combine steam treatment at 85°C for at least 91 seconds with pressing.

3.3.3. Deferred cooling of pellets

This treatment is applied to a press cake that has been steam treated at a temperature of 55°C for a duration of 23 seconds. The temperature of the pellets at the unit outlet is 88°C. Keeping the pellets at this temperature in a thermally insulated chamber enables salmonella to be eliminated. As a consequence, the percentage of positive samples falls from 100% at the conditioner outlet, to 20% at the unit outlet and to 0% after deferred cooling.

It should be noted that this treatment technique results in a 2-point reduction in the durability of pellets.

4. Discussion and conclusion

The results of steam treatment tests, carried out **in a pilot workshop** on products that are artificially or naturally contaminated, reveal that treatment temperature is an overriding factor in reducing salmonella and enterobacteria populations.

For bacteria other than salmonella, an influence of temperature and treatment duration is still observed.

From all of these results it is possible to determine that, within the framework of these tests in a pilot workshop, the minimum treatment conditions are:

- for steam treatment, a temperature of 87°C and a duration of 3 minutes (Figure 2).
- for steam treatment combined with pressing, a minimum treatment temperature of 85°C applied for 1.5 minutes.

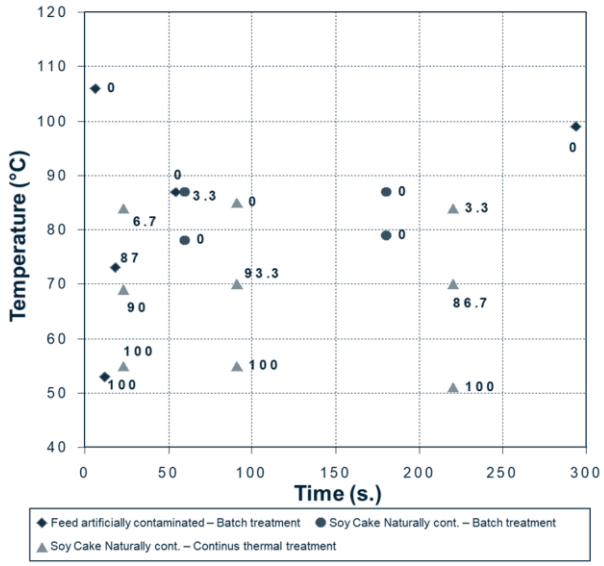

Figure 2: Steam treatment by load and continuous steam treatment

Percentage of samples testing positive for salmonella after treatment

Work carried out **in an industrial setting** by Israelsen (1994) partially confirms these results. In effect, the author demonstrates that, in the case of a mix made from cotton seed press cake naturally contaminated with salmonella, hydrothermal treatment at 74°C combined with pressing does not enable salmonella to be completely eliminated, when the residence time in the conditioner is 13 or 22 seconds.

In the plant, it is essential to take account of other factors, including:

- difficulties controlling the product's initial level of contamination
- difficulties encountered in controlling the distribution of residence times
- the fact that the presence of fats in compound feed may reduce friction in the unit and may have a protective effect as regards salmonella

In industrial practice, this means that, to obtain an effective treatment, it is necessary to create safety margins. Consequently, the minimum treatment conditions should be:

- for a feed meal, 85°C for an average residence time of at least 5 minutes,
- for feed pellets, 85°C for an average residence time of 2 minutes, provided that the rise in temperature during the course of pressing is sufficient for the product temperature at the press outlet to be at least 90°C.

5. Bibliography

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The application of these recommendations in plant should be possible if the operators have a good command of:

1. The parameters for treatment, temperature, residence times and, specifically, distribution of the residence time in the conditioner.

2. The issue of heating up the processing line and starting batches.

3. The plant's hygiene and, more particularly, the downstream end of the processing line, including that of bulk delivery trucks.

All of this needs equipment to be adapted and a procedure to be put in place. All of these actions represent a significant cost for a manufacturer of compound feed.