Scientific dossier

Extruded pigeon feeds: new insights and trends

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PART 2:

EXTRUSION PELLETS AND INTESTINAL HEALTH

INTRODUCTION

In a previous article, we explained how extruded feed enriched with biological anti-oxidants reduces oxidative stress during muscular exercise resulting in better performances and faster recuperation.
The new generation of extruded pigeon feeds with nutraceuticals also promotes the pigeon's health and immunity outside the competition season.

This article considers how extruded pigeon feed can improve intestinal health. Indeed, heat treatment during the extrusion process improves digestibility of the feed and helps to prevent intestinal infections. The pellets also make it possible to add bio-active components such as prebiotics, organic trace-elements, clay minerals, and organic acids to the dietary ration. These components improve intestinal health.

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The gastrointestinal tract is the biggest immunity organ in the body and forms an important barrier with the outside world. And so, the digestive system not only has to receive nutrients, but also keep pathogens out of the body. Feed has an important influence on this intestinal immunity. It is the mission of all innovative pigeon feed producers to transfer all the knowledge currently available in this field into a new generation of pigeon feeds to provide the intestines with maximum protection.

THE EXTRUSION PROCESS IN BRIEF

The extrusion process is a modern production process in which the feed components are exposed briefly to a combination of heat, pressure, and steam. Once the various ingredients have been ground and mixed, they first pass *the preconditioner*. Water and steam are added to the mixture in the preconditioner and this mixture is then moulded into a paste. The temperature in the preconditioner is between 60 and 80°C. The mixture stays in the extruder for about 4 minutes.

The *actual extrusion* happens in the extruder. This is where the paste undergoes various consecutive treatments. The basic component of the extruder is the screw propeller,

which drives the paste. Initially, the paste, is transported, mixed, and kneaded. As the paste slides further into the screw propeller frame, it is exposed to higher pressures and temperatures. The high pressure is created by the fact that the groove in the screw propeller gets smaller and smaller at the end. During extrusion, the temperatures briefly exceed 100℃ and the pressure rises to several times the atmospheric pressure. The die is found at the end of the screw propeller. The die is a steel plate with several openings through which the hot mass of feed is pressed. Shortly after the die, a rotating blade cuts the product strands to size. When the kibbles leave the extruder, they have a moisture content of about 20℃. For ideal storage, the pellets are first dried and cooled down to the surrounding temperature before they are packed.

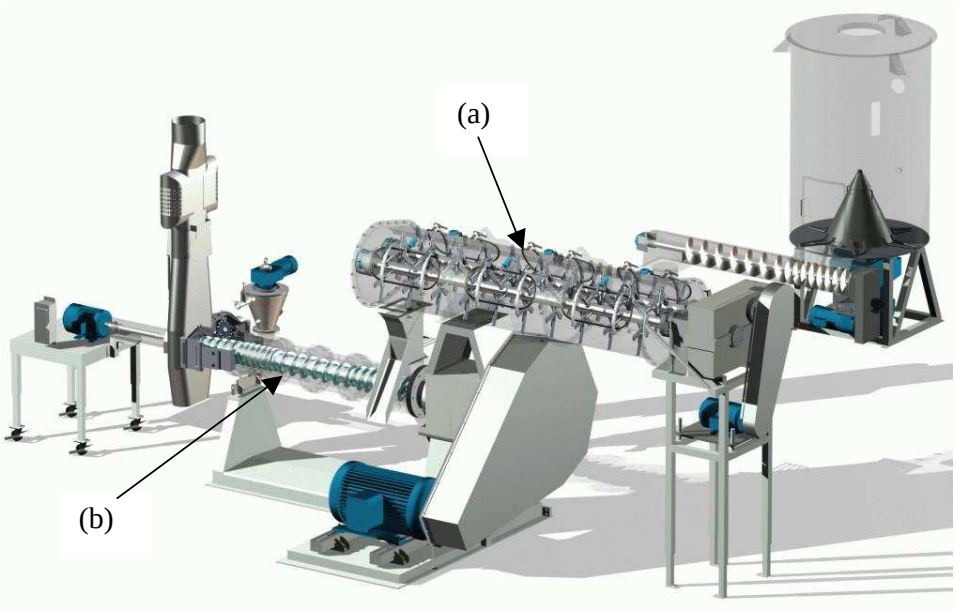


Image: The extrusion process includes 2 phases: the preconditioning (a) and the actual extrusion (b).

EXTRUSION AND DIGESTIBILITY

Elimination of phytotoxins and anti-nutritional factors (ANF)

Several grains and seeds naturally contain phytotoxins or 'anti-nutritional factors (ANF)'. These are toxic substances which are produced by the plant as defence mechanisms against plant diseases. These anti-nutritional factors reduce the availability of the nutrients in the digestive system. Some ANF can even cause acute toxicity if they are consumed in high concentrations, but the main concern is the effects of consuming small quantities of ANF over long periods. ANF include enzyme inhibitors (protease and lipase inhibitors), oligosaccharides, lectins and tannins, and mineral binding agents, such as phytate.

Most of these anti-nutritional factors are inactivated by means of heat treatment. Scientific research has shown that extrusion is the best way of destroying these anti-nutritional factors (Van der Poel, 1989, R. Alonso, 2000). Extrusion hereby improves the availability of starch, fat and proteins for birds (Spais, 1997).

ANTI-NUTRITIONAL FACTORS IN PIGEON FEEDS

Enzyme inhibitors *are protein-like substances which can hinder the activity of enzymes. They are found in legumes, especially soya and beans, in grains, especially rye and triticale (a cross between rye and wheat), and in some seeds like sunflower and cotton seeds. Well known examples are inhibitors from trypsins and amylase. Trypsin-inhibitors, for example, hinder the digestion of proteins.*

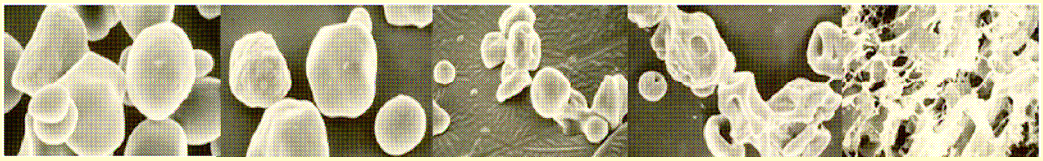
Lectins or haemagglutinins *are proteins which are found in legumes, especially in soy, beans, and peas. They can cause red blood cells to clump together and inhibit the absorption of nutrients by means of an interaction with the gut wall. The latter effect results in stunted growth. Many lectins cannot resist heat, so extrusion prevents the harmfull effects of lectins.*

Phytate *is a cycliccompound which is often found in plants. Together with calcium, magnesium, zinc, copper, and iron, it forms insoluble compounds. This can reduce the availability of minerals. The extrusion ensures that the effects of phytate are partially nullified.*

Starch gelatinisation

Uncooked starch is enclosed in a grain structure which makes it largely inaccessible for digestion. The starch can only be used if the digestive enzymes can reach the starch and then decompose it to form glucose. Heat treatment makes starch more digestible for most sorts of animals. Indeed, heat treatment damages the starch grains so to make the starch components more accessible for the digestive enzymes.

Loss of the grain structure in starch during extrusion
(microscopic image 2000X)

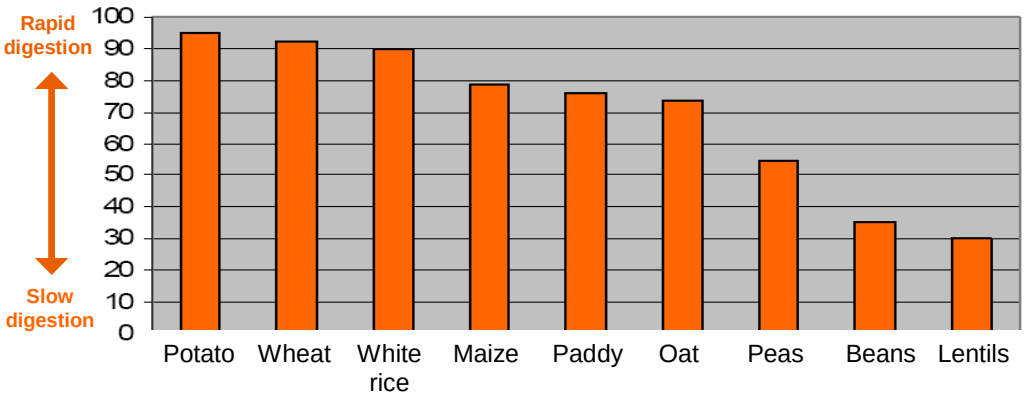


Uncooked starch → *gelatinised starch*

The loss of the grain structure in starch is caused by the addition of heat and water. First of all, the water penetrates the starch grains and causes them to swell. The addition of even more water and a rise in the temperature causes the starch grains to swell even more. Consequently, the grain structure disappears completely and the starch components are disentangled. This makes the starch more accessible for the digestive enzymes. Actually, the same changes occur when we bake bread or boil potatoes. Human beings, too, digest easier gelatinised starch.

Whereas maximum starch gelatinisation is the objective with mammals, recent studies have shown that with birds it is better to aim for a more limited cooking of starch. After all, it is important with birds that the supplied starch is digested slowly so that they do not digest all of their food in the first part of the small intestine, but spread it throughout the entire small intestine (Weurding et al, 2003). By adapting the size of the particle (grinding fineness), the type of starch (each plant contains a different type of starch), and the extrusion parameters, it is possible to optimise the speed at which the starch is digested. Feeds with starches which are digested slowly improve the utilisation of proteins and other nutrients in birds. Recent studies in pigeons (Abd El-Khalek et al, 2009) have shown that a limited release of starch also results in a lower, healthier pH (acidity) of the intestine and better consistency of the faeces.

The glycaemic index (G.I.) of the various sources of starch



Graph: In addition to the heat treatment and grinding fineness, the origin of the starch also determines the rate of digestion. The dietary ration of pigeons must contain enough slow digesting starches (= starch with a low glycaemic index i.e. on the right side of the graph).

EXTRUSION AND HYGIENIC FEED QUALITY

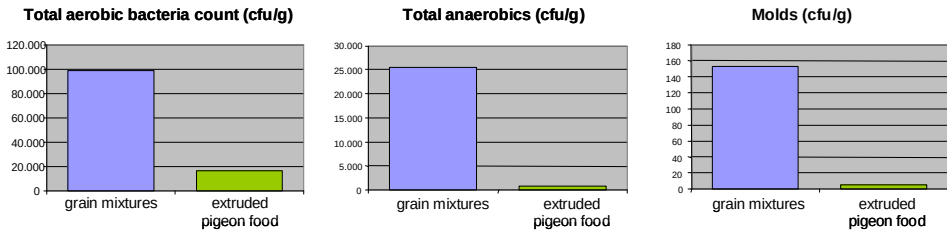
The high temperature and pressure to which the feed is exposed during the extrusion process not only improve digestibility, but they also have an extremely beneficial effect on the hygienic and microbial quality of the feed.

The sterilisation effect: bacteria, viruses, yeast, and fungi are destroyed

During the extrusion process, the temperature rises to between 100 and 130℃. these high temperatures kill any pathogenic micro-organisms which may be present in the raw materials:

- Coliforms, salmonella, and listeria bacteria are destroyed using heat treatment of 70ºC for 1 second. And so, under the normal processing conditions, the feed is completely pasteurised (i.e. all bacteria are killed).
- Viruses, too, are destroyed by extrusion.
  The avian influenza virus (bird flu) is completely destroyed at temperatures above 70℃.
- Extrusion reduces fungi contents considerably. Contrary to some claims, the risk of fungal and yeast cell infections via extruded feed is much lower than via classical grain mixtures.

COMPARISON OF THE MICROBIOLOGICAL QUALITY OF GRAIN MIXTURES AND EXTRUDED PIGEON FOOD



The above results give the average count of aerobic bacteria, anaerobic bacteria, and molds in pigeon grain mixtures and extruded pigeon food. The germ content in extrudates is much lower and illustrates the sterilising effect of the extrusion process.

Insects

Grains and seeds can be affected by vermin such as mealworms and granary weevils. The grinding process before extrusion and, especially, the high temperatures in the extruder kill any insects present and their eggs.

Table 1 shows that temperatures above 62℃ kill all insects within one minute. And so, when the feed leaves the extruder, it is completely free of living insects.

Table 1: The effect of temperatures on insects

Temperature (℃)	Effect
>62	Insect dies in less than 1 minute.
50-60	Insect dies in less than 1 hour.
45-50	Insect dies in less than 1 day.
30-35	Maximum temperature for reproduction
25-30	Ideal temperature for breeding

Inactivation of enzymes

Raw vegetable products sometimes contain enzymes which cause decay when the feed is stored. These enzymatic reactions can change the taste, smell, colour, and texture of the feeds. A well known example is the lipase enzyme, which is present in a number of seeds and causes the dietary fats to turn sour prematurely during storage. These destructive enzymes are destroyed completely by heat treatment. In this way the extrusion process contributes to better storage and stability of the feeds.

EXTRUDED PELLETS AND INTESTINAL HEALTH

In addition to the benefits of the heat treatment, extruded feeds also have the benefit that they can be enriched with nutritional additives such as vitamins, micro-elements, and nutraceuticals which promote intestinal health. Products can also be added which hinder fungi and/or bind mycotoxins so that the risk of health problems as a result of microbial problems is reduced even further.

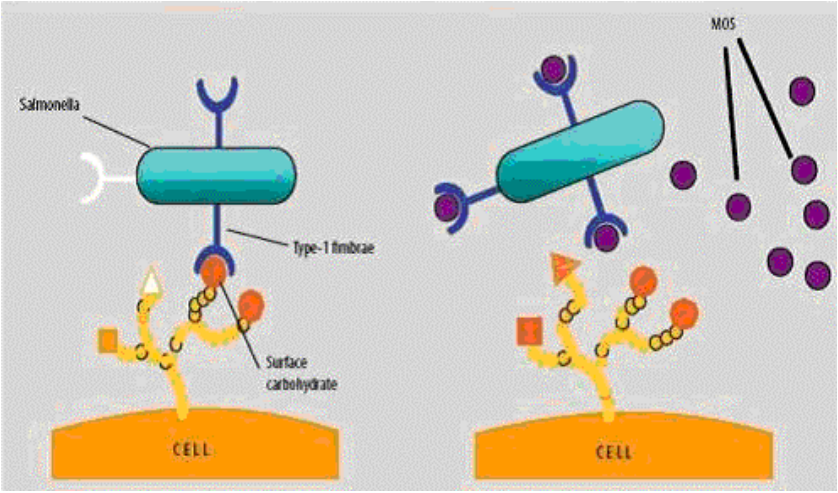
Prebiotics for healthy intestinal flora

Lots of extruded pigeon feeds are enriched with prebiotics. Prebiotics are a type of sugar which has an effect on the bacteria in the intestines. There are billions of bacteria in the intestines. These are usually the innocuous or even healthy bacteria such as lactic acid bacteria and bifid bacteria. However, in addition to the healthy bacteria, there may also be some pathogenic bacteria present (e.g. coliform bacteria or salmonella). We distinguish two sorts of prebiotics, each of which has a different working mechanism.

Fructo-oligosaccharides (FOS) are sugars which promote the growth of the healthy lactobacilli and bifid bacteria. The working mechanism of FOS is based on the fact that only the benevolent intestinal flora can use these special carbohydrates as nutrient. By contrast, pathogenic bacteria are unable to use this FOS as food. Fructo-oligosaccharides have been added to food for humans and animals for years. It is particularly in animal species with a strongly developed intestinal flora that clearly positive effects of FOS have been proved scientifically.

A second sort of prebiotics are the **mannan-oligosaccharides (MOS)**, which are insulated from yeast cell walls. These MOS have a direct effect on pathogenic bacteria by hindering their adhesion to the intestinal wall. The result is that harmful bacteria are separated together with the undigested food via the excrement before they can cause any damage.

Mode of action of MOS:
Left: the salmonella bacterium (blue)attaches itself with its receptors to the intestine wall (orange).
Right: MOS (purple) blocks the receptors of the salmonella bacterium (blue). This means that the bacterium cannot attach itself to the intestine wall and therefore cannot cause any damage.



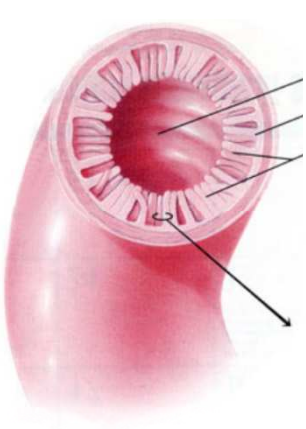
The use of MOS is particularly recommended for pigeons, which have a very limited intestinal flora by nature. Indeed, the mannan-oligosaccharides or MOS have an immediate blocking effect on the harmful bacteria without the healthy bacteria having to be stimulated first. This is why it is preferable to give pigeons MOS.

Research has been carried out recently at Ghent University into the effect of 0.4% MOS in pigeon feed (Abd El-Khalek et al. 2008). With the addition of MOS supplements, changes were noted in the intestines which prove that there is less bacterial pressure. The addition of MOS also resulted in a lower, healthier level of acid and better consistency of the excrement. The researchers concluded that MOS has a generally beneficial effect on the digestive system of pigeons.

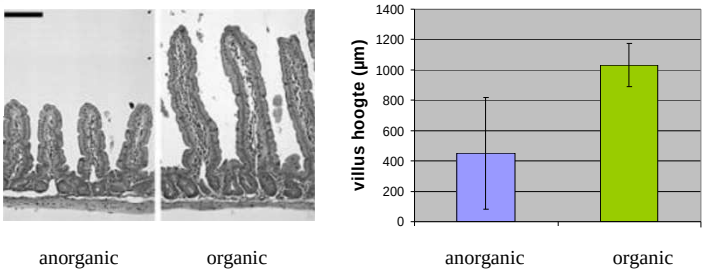
Organically bound micro-elements

Trace-elements are essential nutritional elements which have to be present in the dietary ration in small quantities and play an important part in numerous metabolic processes. Selenium, zinc, manganese, and copper are essential trace-elements which are often not present in sufficient quantities in the traditional pigeon diet. Indeed, in traditional diets trace-elements are almost always present in an 'anorganic' form i.e. less digestible. A new trend is to supplement 'organically bound micro-elements' because these are much easier to digest.

Organically bound trace-elements ensure healthier intestinal villi.



Influence of trace-elements (organic versus anorganic) on the intestinal villi (Abd El-Khalek et al 2010).



A recent study on pigeons with organically bound trace-elements has shown that these better absorbable trace-elements give rise, amongst other things, to higher zinc content in the blood and healthier and longer intestinal villi (Abd El-Khalek E et al 2010).

Clay minerals and organic acids for extra protection

Extruded pellets also mean it is possible to add a number of substances which provide extra protection for the digestive system and general health. For example, clay minerals are very good for promoting intestinal health. Some clay minerals help to prevent diarrhoea because of their water binding capacity and improve the consistency of the excrement. Moreover, they can also neutralise any mycotoxins and/or pesticide residue which may be present in the grains and thereby reduce the health risks related to these toxins. These clay minerals also have a smell binding effect and reduce ammonia concentrations in the dovecote. Organic acids are also sometimes processed in extruded pigeon feed. These natural acids ensure a lower, healthier level of acid in the digestive system and hinder the growth of fungi and yeast.

Conclusion

Scientifically formulated extruded pigeon pellets promote intestinal health in various ways. The high temperatures inactivate the anti-nutritional factors and gelatinise the starch to improve digestion. Moreover, the heat treatment has a sterilising effect and thereby brings about a spectacular reduction in the number of micro-organisms (microbes) in the feed. Analyses have shown that extruded feed contains on average ten times less fungi than classical grain mixtures. The extruded grains also make it possible to add nutraceuticals such as prebiotics and organically bound trace-elements which promote intestinal health. The use of clay minerals and organic acids provides added protection for the digestive system.

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