THE PRODUCTION PROCESS OF EXTRUDED KOI FEEDS

Based on hands-on experience of many years' standing and unrelenting research efforts, Versele-Laga has built a reputation as one of the world's leading manufacturers of foods and feeds for pet animals. Thanks to the collaboration between between exotic fish and koi fish breeders on the one hand and the Versele-Laga's scientific team of veterinarians and nutritionists on the other hand, the company has developed a comprehensive and innovative range of feeds for koi and other fish varieties which are marketed under the Fishlix label.

Fishlix Koi Staple
Growth 2mm

Fishlix Koi Staple
Medium 4mm

Fishlix Koi Staple
Large 8mm

Image 1:
Versele-Laga produces a range of high quality fish feeds of different-sized pellets for koi fish specifically geared to the size and age of the fish.

In this article, Dr. Guy Werquin, veterinary surgeon-nutritionist with Versele-Laga's R&D department, explains how extruded ornamental fish feeds are produced these days, describing the various stages in the development and production of these feeds.

1. THE FORMULATION :
ESTABLISHING COMPOSITION AND INGREDIENTS

The first step in the development of the feed is formulation. Basically, what this means is that a formula or recipe is established in which the ingredients
are combined into a product with a composition which duly meets the nutritional requirements of the animals concerned. Today, this is done using specialist computer software programmes which resort to so-called linear programming. It is the nutritionist who keys in, which parameters the feed is required to comply with: contents in terms of proteins, amino acids, fats, carbohydrates, vitamins, minerals, micronutrients, energy, etc. are defined with great accuracy. For this, the nutritionist draws on the latest findings available in scientific veterinary-nutritional literature.

Ingredient quality

The prime concern in the formulation and production of fish feeds is the quality of the ingredients. Feeds that are manufactured using inferior quality raw materials have a sub-standard nutritional value and are certain to have an adverse impact on the condition of the fish. At Versele-Laga, ingredients are subjected to particularly rigorous quality standards, laid down under the HACCP quality control system.
Not only the composition of the ingredients is crucial, biological aspects such as digestibility and availability of raw materials are also essential parameters. Freshness and drying techniques used in the processing of the protein components are the deciding factors in this.

Fish products

The protein source in koi feeds is usually derived from fishmeal. Very often, the fishmeals that are available in the trade tend to show up huge differences in terms of quality, depending on the quality of the fish and the processing operations used. What is paramount is the freshness of the fish: processing should be made to occur as soon as possible after catching. Spoilage of the fish causes the nutritional value to plummet, as well as releasing potentially toxic subtances such as histamine, cadaverine and agmatine.

Vegetable by-products

A variety of different vegetable proteins and cereal by-products are frequently processed in fish feeds. Certain vegetable proteins have a high nutritional value (high digestibility, high levels of essential amino acids).
Other vegetable products serve to improve the physical properties of the pellets. The use of vegetable raw materials most often requires heat treatment, which destroys the anti-nutritional factors whilst rendering the starch more digestible.

Fats and oils

Fish oil is the principal source of fat in koi feeds. Fish oil is an excellent source of omega-3 fatty acids (EPA & DHA). These essential fatty acids are crucial for the condition of the koi fish. Other varieties of fat such as vegetable oils or fats derived from mammals can also be used in koi feeds, yet a minimal amount of fish oil is indispensable to infuse the feed with EPA and DHA.

Fish oils are poly-unsaturated fatty acids which are particularly prone to oxidation (turning rancid). Rancid fats adversely affect some of the nutrients that reside in the fish feeds, and therefore have an adverse impact on the condition of the fish.
Amongst other things, liver disease (such as “Fatty liver disease”) is caused by feeding the fish rancid fats.
Which is why it is paramount for fresh oils and fats to be used in the production of fish feeds. The addition of antioxidants serves to protect the fats against turning rancid.
It is very important for the dosage of these antioxidants to be closely monitored and checked by way of laboratory analyses. At Versele-Laga, these checks are systematically conducted using rancimat analyses, in which the fats are subjected to accelerated ageing at the lab in order to verify their protection levels against oxidation.
Koi hobbyists too are advised not to feed their koi fish rancid feeds. Rancid fats are easily told by the way they smell. Feeds that give off a rancid smell are best disposed of.

Afbeelding 2: *Fats are subjected to accelerated ageing in order to verify their protection against oxidation levels.*

Natural pigments: carotenoids

Obviously, it is the colour of the koi fish that is one of the features to appeal to hobbyists. Although the colouration of the koi is genetically determined, the diet they are fed also plays a significant part in bringing out their colours to best effect.
The reason for this being that some hues cannot be synthesised by the fish themselves, requiring to be supplemented through the feed. For the red amber colour especially, the supply of carotenoid pigments in the feed is essential. Living organisms which are rich in carotenoid pigments are widespread in nature (e.g. in the shape of Daphnia crayfish). Kois absorb these organisms from birth. Following a series of different metabolic processes, the pigments are stored in the body cells. In koi feeds, carotenoid colourants are usually introduced by way of krill crustaceans (animal source) and spirulina (vegetable source). Too much krill is to be avoided as this may cause the white background to fade in addition to having a laxative effect.

Spirulina algae are a very good source of natural carotenoids. Spirulina algae are primitive organisms which live in seawater and which use photosynthesis to convert the carbonic acid dissolved in the seawater. Algae are one of the most ancient life forms on earth. A primal source of food, algae have been around for over 3.5 billion years. Not only are algae rich in carotenoids, they also contain a good deal more essential nutrients. They are a rich source of proteins and amino acids (60% protein), micronutrients and essential fatty acids. Which explains why no koi feed should be without spirulina algae.

Image 3: *microscopic image of spirulina Spirulina is the botanical name for blue-green algae which is barely half a millimeter long. The Latin 'spirulina' means 'tiny spiral' and refers to the coil shape of the alga.*

More recent research has identified the specific pigments which koi fish store in their tissue and synthesise from the wide range of carotenoids which are introduced through the natural food sources. These latest insights enable koi feeds to be supplemented with the specific carotenoids in a pure and easily available form. The result being that faster-action additives such as pure beta-carotene, astaxanthin and canthaxanthin (the concentrated pigments which are effectively used by the koi fish) have made their entry in the formulation of koi feeds.

Immunity stimulators

Pond fish live in an environment where they are constantly exposed to potential microbial pathogens. As a result of the artificial environment they live in, the koi fish which are kept as a hobby are very often subjected to different forms of stress caused by being handled, by transport, overpopulation, exposure to pollution and contamination, infections, etc. These different stress factors make it very difficult for the natural defence mechanism of the fish to contend with the infection pressure. An increasing body of scientific studies shows that stimulating the immune system through the diet the fish are fed is an efficient manner of improving the condition of the fish and preventing disease.

Especially â-glucans have been shown to stimulate the non-specific immune system of fish, when administered through the diet. â-glucans are non-digestible components of the cell wall of yeasts. Versele-Laga's Fishlix koi feeds are supplemented with a pure â-1.3/1.6-glucan derived from bakers' yeast (Saccharomyces cerevisiae). This serves to activate the macrophages and the Natural Killer cells of the immune system, producing improved immunity against disease and illness as a result.

Vitamin C too is essential in the koi diet, providing resistance against illness as well as boosting tissue repair. Vitamin C not only supports immunity, it is also a very powerful biological antioxidant which protects the body cells against the baneful action of free radicals. Until recently, vitamin C deficiency was rife among koi because regular vitamin C (ascorbic acid) is easily damaged during the fabrication process (heat treatment) whilst also being quick to lose its action when stored. Recently, a new type, phosphorylated vitamin C has become available which is far more stable as well as being resistant against the heat treatment it is subjected to during the extrusion process. It is important for koi feeds to be produced incorporating this new, more stable vitamin C.

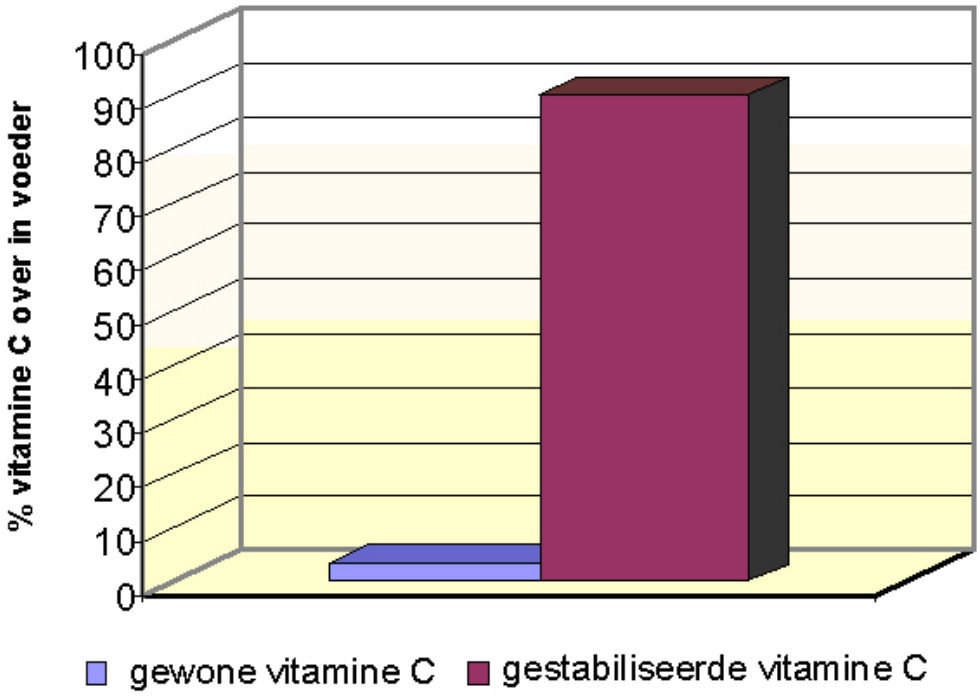


Image 4: *proportion of vitamin C left following extrusion when respectively using regular vitamin C and stabilised vitamin C*

2. THE ACTUAL PRODUCTION PROCESS

Blending and grinding the various raw materials

Once the nutritionist has computed a recipe with the assistance of the computer , all ingredients are assembled in a mixing tub. This is usually done in a computer-controlled mixing workshop. Here, all ingredients are blended into a consistent compound mixture.
The next step is for this mixture to be milled by hammer mills into a sufficiently fine meal. Any particles which have not been milled finely enough are simply sieved off. To preclude any errors, the composition of all mixtures is checked in the food laboratory. Here, the different parameters of the feed are duly examined and checked: protein content, ash content, fat content, etc. Only when all parameters that have been duly checked are compliant with the values as stated by the computer, the meal is cleared for extrusion.
All of this serves to trace any mixing errors or anomalies in the raw materials used in timely fashion.

The extrusion process

Today, most fish feeds are produced by way of extrusion technology. For optimal digestibility, it is required for the feeds to be subjected to thermal processing, in which anti-nutritional factors are destroyed and the starch is duly broken down.
Unboiled starch is locked inside a granule structure which makes it difficult to digest. Which is why the starch needs to be " broken down" beforehand. In doing so, the starch granules are damaged causing the starch components to become more readily accessible to the digestive enzymes. For this starch break-down (= gelatinisation) to occur, both water as well as heat injection are needed. In the first instance, the water infiltrates the starch granules, making them swell. Through the addition of more water still as well as raising the temperature, the starch granules continue to distend even further, causing the granular structure to disintegrate and the starch components to unravel. This renders the starch more readily available to the digestive enzymes.

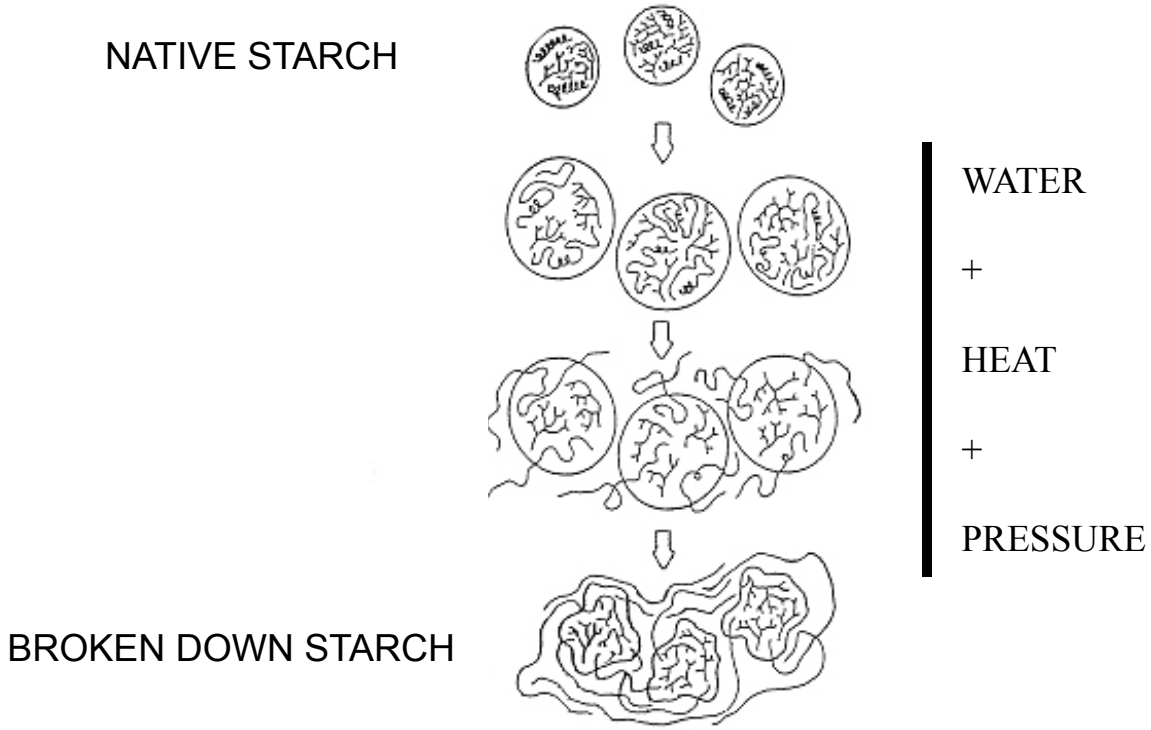


Image 5:
swelling and desintegration of the starch granule during gelatinisation

These are basically the same changes which occur when we bake bread or boil potatoes: humans too digest starch which has been broken down to better effect.

The best way to unlock starch is through extrusion, as this modern technology uses the combined effects of temperature, pressure, moisture and expansion.

The extrusion process takes in two separate phases: the preconditioning phase and the actual extrusion.

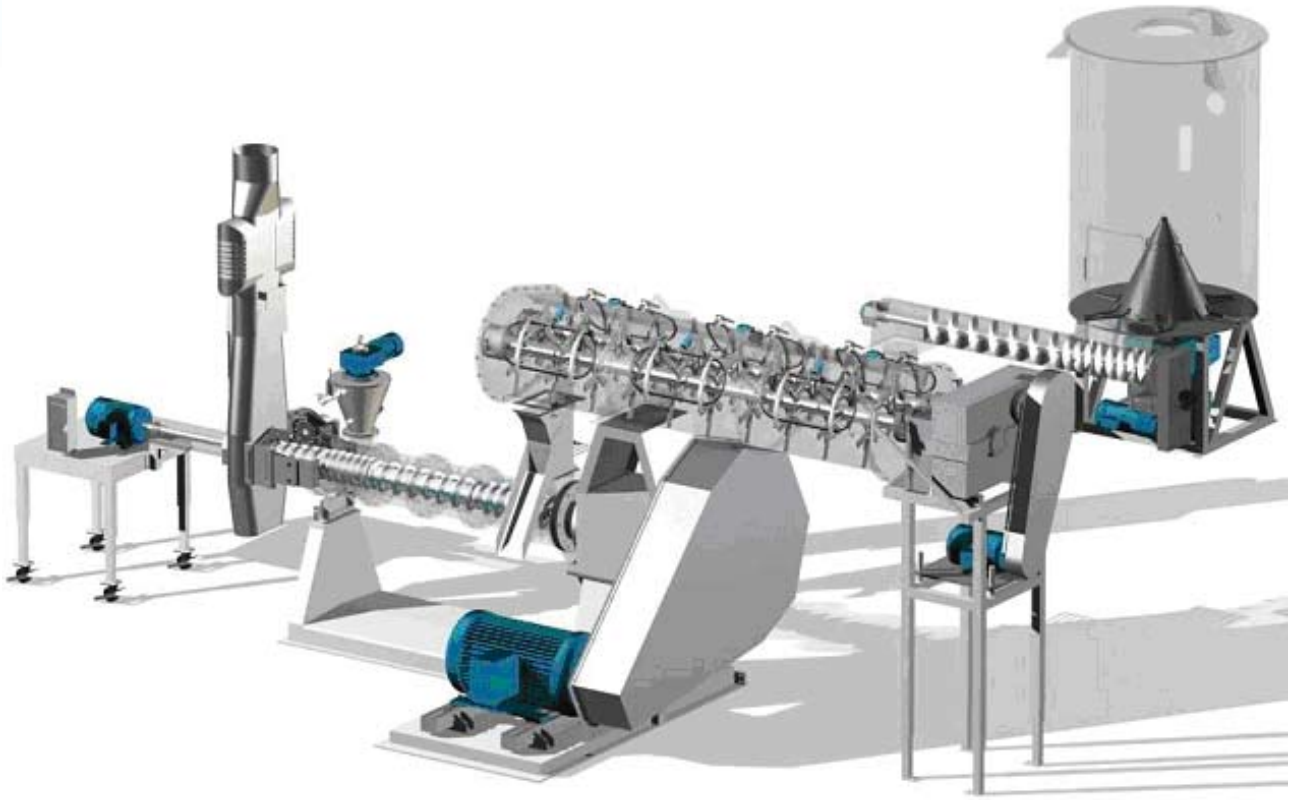


Image 6:
The extrusion process consists of 2 phases: the preconditioning (a) and actual extrusion (b)

a) the preconditioning phase

The preconditioning phase takes place inside the mixer just before the extruder.
Here, steam injection is used to bring the temperature and the moisture level up to best favourable levels for processing inside the extruder.
On average, some 15 to 20 % of moisture is added. Inside the mixer, temperatures are around 65 to 80 °C. In addition, this is where the feed pulp is worked into a consistent dough, ready for extrusion.

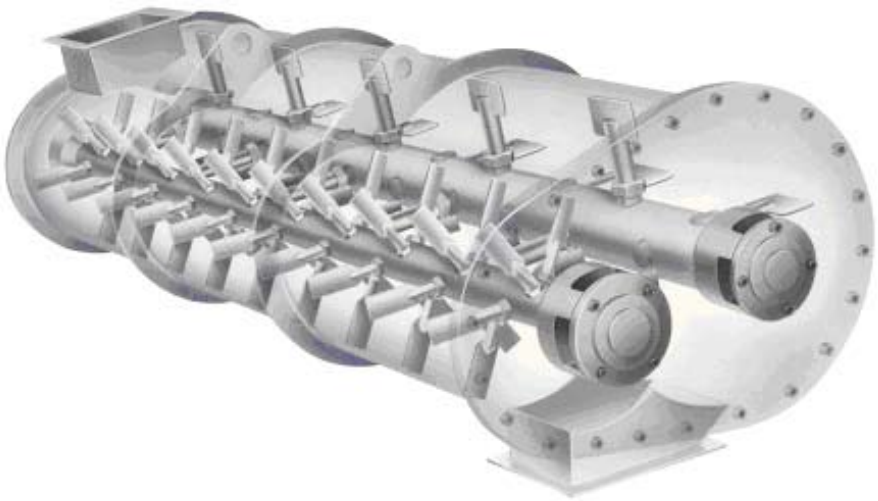


Image 7:
Inside the preconditioner, the meal is worked for some minutes after it has been injected with steam. This phase is akin to kneading dough.

b) actual extrusion

Inside the extruder, the dough is subjected to a series of subsequent processing steps. The principal component of the extruder is its rotary propeller which kneads and propels the dough. Initially, the dough is conveyed, mixed and worked. As the dough continues its way along the propeller shaft, it is subjected to increasing levels of pressure and heat. The high pressure is caused by the fact that the groove in the propeller at the end becomes increasingly smaller in size.

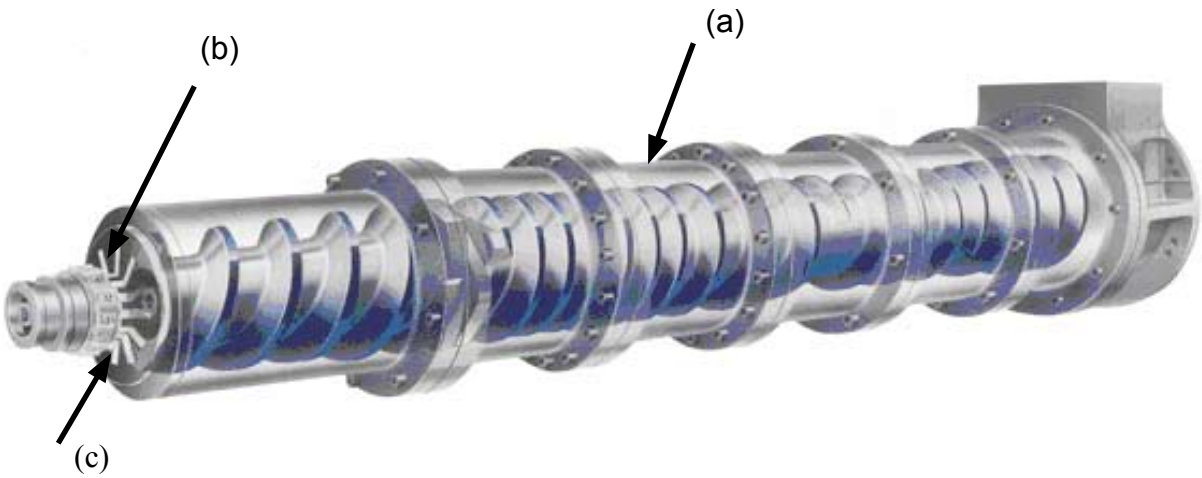


Image 9: *The actual extruder: the principal component is the rotary propeller (a). At the end of the propeller sits the extrusion die (b). A rotating blade (c) cuts the product hanks to the required size.*

At the end of the propeller sits the extrusion die. The die is essentially a steel plate containing a series of slots which the hot feed mash is force-pressed through. The size and shape of these slots determine the size and shape of the finished product.

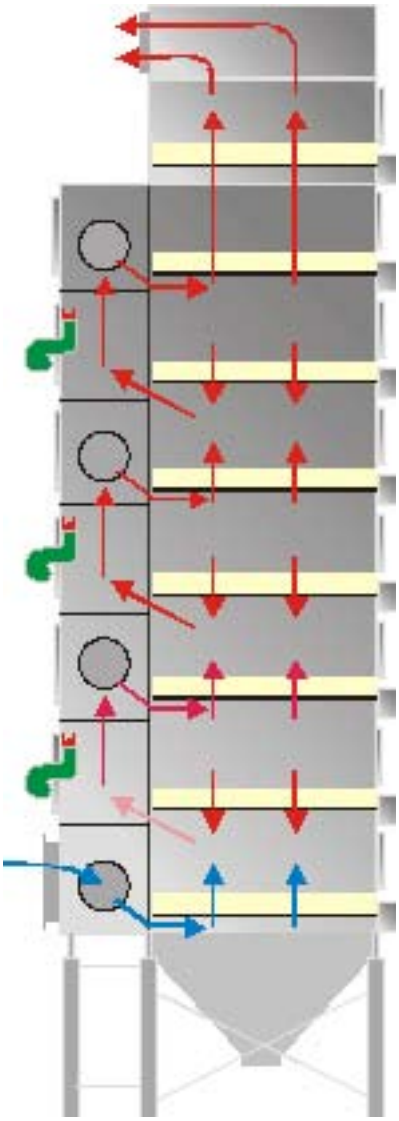
Behind the die sits a rotating blade which cuts the product shanks to size. The higher the rotating speed of the blade, the shorter the size the product is cut and the flatter its shape.

Image 10: *the extrusion die plate is able to hold dies of different shapes*

As a result of the sudden pressure drop after the die, expansion is made to occur causing the granules to expand in volume up to four times their original volume. The density of the pellets is determined by the pressure before the die. In the fabrication of fish feeds, the density of the pellets is a particularly important parameter which has to be closely monitored. All the more so as it is the density of the pellets which determines whether the feeds will float, sink or remain suspended in the water.

The dryer

Upon leaving the extruder, the product has a moisture content of around 20 %. To avoid spoilage, it is imperative for the products to be dried. This is done inside the dryer. Here, hot dry air is sent out to overspread the product. The dryer is set to such a level that the granules leave the dryer having a 9 to 10 % moisture content. The product's moisture content is continuously monitored and adjusted at the end of the dryer to prevent unduly high moisture levels and any spoilage that this may bring.



Images 11 & 12:
At Versele-Laga, the pellets are sedulously and consistently dried using a modern, vertical "counter-flow" dryer.

The vacuum coater

Image 13: *the vacuum coater*

In fish feeds, most oils and fats are added following extrusion. The way this is done is with the fat being sprayed onto the granules, after the dryer. Previously, this processing step was usually performed inside a regular rotating drum coater. Modern production plants have increasingly turned to using vacuum coaters as these allow for a meticulous dosage of the fat on the fish feed pellets. The dosage of the fat inside the vacuum coater is not only far more accurate, this new technology also allows higher quantities of fat to be coated on whilst injecting the fat deeper into the

granules. This makes for a less greasy looking granule which in turn is less capable of contaminating the pond water.
The vacuum coater consists of a closed mixing system which has mixing propellers and a spraying system at the top. Vacuum pumps are used to evacuate the air from the product (2). The next step is for the fat to be sprayed onto the surface of the pellets (3). Afterwards, the air is let back into the vacuum coater in which, as the atmospheric pressure returns, the fat permeates into the pores of the granules taking the place of the air (4).

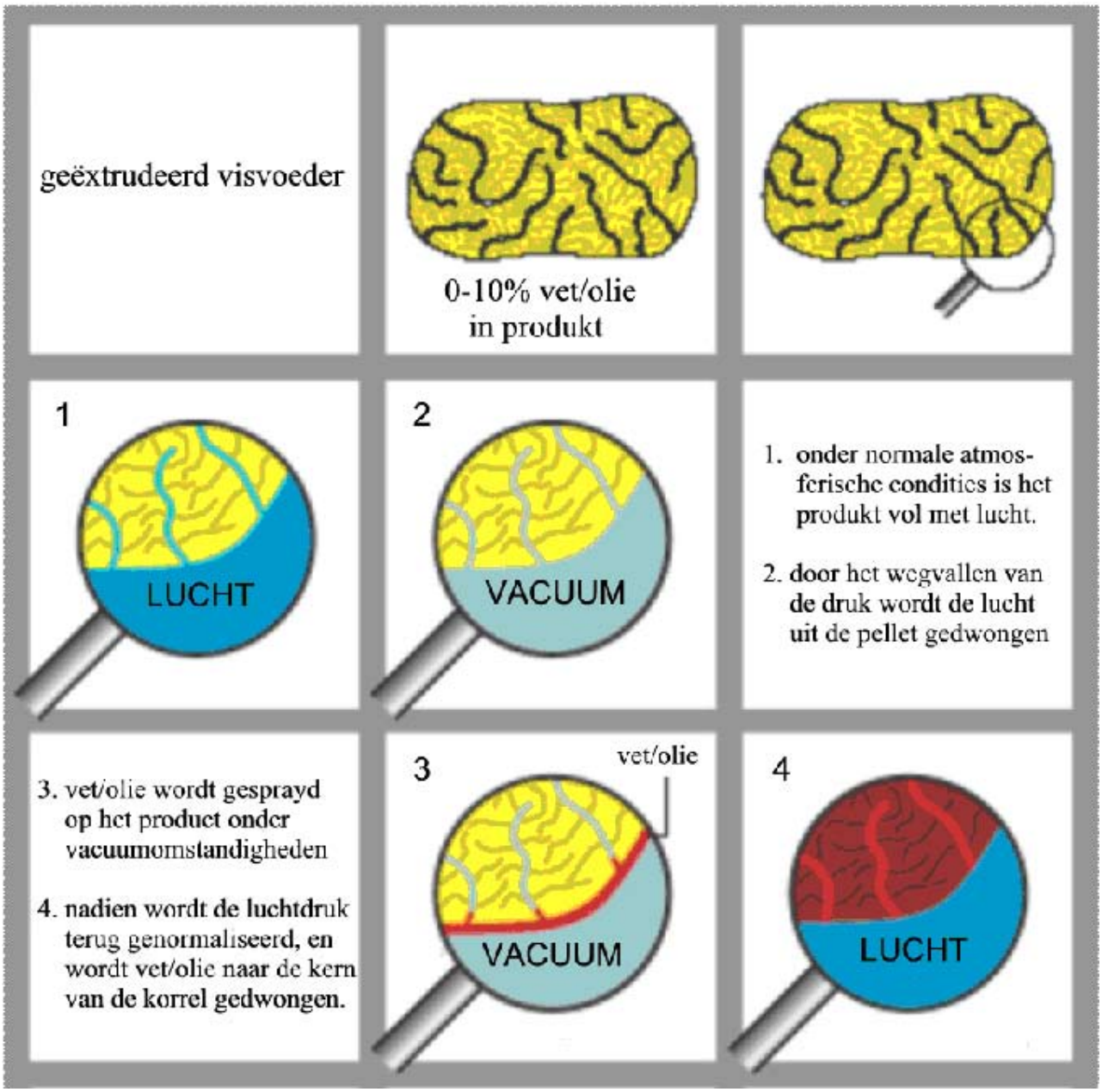


Image 14: *the different stages during vacuum coating*

The cooler

After the dryer, the pellets are conveyed to the cooler. This installation serves to cool the granules down to the ambient temperature. Once the products have sufficiently cooled down, they are packed as soon as possible.

Packing

The final step in production is the packing of the finished product. At Versele-Laga, fish feeds are packed in a separate section of the plant. The appropriate quantities of feed are accurately weighed and dispensed in the final packing receptacles inside automated packing installations before a batch number and the sell-by date are printed on the packing covers.

Author:
Dr Guy Werquin
Veterinary surgeon - nutritionist
R & D Department
Versele-Laga
Kapellestraat 70
B-9800 Deinze
Belgium
Tel: 09 / 381 32 00