

Mealworms and Foods: Food for People and Fish

New Generation Nutrition (NGN) in Den Bosch

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In September 2015, the NGvA's activities committee in the Groene Welle in Zwolle organized a mini-symposium on new proteins in fish farming, and in the October issue of Aquaculture, an accompanying report was published (1). Attentive readers will have noticed that the speakers had promised the editors of the magazine that they would go into further detail about their story. So, we have thrown out the nets, patiently waiting for an inspirational story from these speakers. Fortunately, on Wednesday afternoon, May 24, I am sitting for coffee with Marleen Vrij, one of the two directors and founders of NGN (New Generation Nutrition, <http://ngn.co.nl/>) in Den Bosch and I'm also meeting some HAS students (and a student of Thomas Moore (BE)) completing their practical experience (Figure 2). On to the subject of fish production, feeding costs amount to 40 to 50% of the production costs of breeding fish. Fishmeal and fish oil are essential and precious ingredients, which are certainly not fully replaceable by vegetable proteins and fats. When putting a spotlight on carnivorous fish, it can be seen that many of them naturally feed on insects. NGN wants to use large scale insects (proteins) as an alternative source of animal protein for human consumption and animal feed. With our coffee, muesli and cookies served with the addition of crickets, and the taste is surprisingly similar to dried pineapple! (Figure 1).

Marleen Vrij: an Adventurous Entrepreneur

Graduating as a food technologist from Wageningen, working for 20 years in Nutreco's R & D department, followed by 4 years as a consultant for Zetadec, Marleen decided in 2012 that she would like to work with Marian Peters in developing a new start-up: New Generation Nutrition (NGN). NGN wants to contribute sustainably to global demand for animal proteins by processing insects into food for humans and animals. Peters brought her Wageningen knowledge, ability to connect people and resources, and international experience as one of the founders of VENIK. Currently, NGN employs 5 people and has a continuous flow of trainees. Vrij: "People often think that you will be rich as an entrepreneur, but it is especially hard work for little money. We started in 2012. Now, just slowly, we've started to get the ball rolling. At Nutreco I never thought about what it takes to do research, or run a company. Now, I know better. Fortunately, I do not have to know everything right away. The company is gradually growing with us".

NGN Pro-Active and NGN-Products

By means of a diagram (Figure 3), the organization of NGN consists of 2 operating companies: NGN Pro-Active and NGN-Products. NGN-Products does not make much revenue of any significance; virtually all sales are from consultancy, education, and networking. NGN is active in Nigeria, Kenya and Uganda with knowledge about the cultivation and processing of insects (black soldier fly) into products for human food and as a source of protein in feed for chickens and pigs. These projects are in collaboration with TNO, HAS Den Bosch, Chemonics and USaid. Another project (Kip en Ei) was done in collaboration with Coppens Diervoeders, Protifarm (Kreca), and the Louis Bolk Institute in Driebergen. In addition, in cooperation with the HAS Den Bosch and the University of Wageningen, both shorter and longer courses will be given to Dutch and international entrepreneurs who want to produce insects or want to know more about the insect chain and the functional qualities of insecticidal products, with courses based in the Netherlands (Figure 4).

Vrij and Peters are also very active as promoters of the other elements mentioned under Pro-Active. For example, Peters contributed to "The Insect Cookbook" (2) and many strategic studies that indicate how and why insects could be used extensively in a cyclical food industry (including ABN-AMRO Small Sector Large Opportunities). Peters is also one of the founders of the IIC (International InsectCenter), which is based at NGN. IIC serves as a platform and knowledge network for 100 companies that are internationally active in this young sector. Vrij also brings the technological possibilities and functional properties of insect protein and the various formulations to the attention of potential users, with research carried out by employees and interns into applications and composition of insect products (Figure 5).

The Law and the Possibilities

Legal restrictions have, for the most part, prevented the use of insects as a feedstock due to precautions surrounding mad cow disease (BSE). As a result, it has been prohibited within the EU since 1991 to feed animals with animal proteins from the bio industry (Regulation EC No 999/2001). This also applies to farmed insects. During her presentation to the NGvA in 2015, Vrij saw this ban as the main obstacle to the substantial use of insects in the animal feed industry. By the end of 2016, the European Commission approved an amendment to the regulation, which eliminated the ban on insect proteins from 1 July 2017. Vrij: "It is of course a case of seeing is believing. We now want to carry out an extensive test on animal and vegetable by-products from the agricultural chains. We thought that we had found a good location for a pilot plant, but the NVWA points out its shortcomings and, in consultation with them, we want to work towards obtaining a permit. If we then want to set up such a pilot, then we talk about a mega investment. We are now talking to an investor who understands what we are talking about. After arranging this, the producers must be willing to collaborate with the insect farmers, because for a pilot plant we need larger amounts of raw material to work with."

Large feed producers are still investing in such initiatives and it is expected that they'll be the first to be able to produce fishmeal alternatives on a large scale to supply the market. Vrij: "Nutreco definitely sees opportunities in insect meal, only the price and the quantities are not yet sufficient. For example, a producer that can deliver two tankers a week is not yet good enough. She explains why this is a chicken and egg issue: the big companies are interested in risk-free products that are available in bulk and meet an existing market demand. Because legislation so far has not allowed insect meal in animal feed, there was no question. And if there is no question or product to sell, it is also difficult to find investors and to scale up the production of insects. This stagnates the development of insect culture on an industrial scale, which means that the cost per kilo of protein remains relatively high. With only small players in the field it is difficult to put pressure on the legislators and to change rules. And if you want to change the rules, European Union (EFSA) and NVWA documentation will be required to demonstrate the safety of each insect and product. This requires costly and large-scale research that these small businesses can't provide. The Dutch VENIK and the IPIFF, a European platform of companies that breed insects, bundle research efforts for registration and developments in the sector (3). Vrij: "We'll be there, but it's going to be very slow going."

How can it be, considering all of these barriers, that Sligro and some delicatessens and webshops have locusts, buffalo worms, crickets, flour worms and such frivolities in their assortments? Vrij: "That's a little complicated, but those suppliers make use of a hole in the law. Insects are not forbidden for human consumption, but also not really allowed, so it is a difficult grey area. Insects are considered a Novel Food, so soon there will be legislation indicating which insects can be bred and how they should be processed. Of course, they must produce according to HACCP, but it cannot be forbidden until the new legislation is in force. "

NGN: From Wageningen to Den Bosch

"We first sat in Wageningen and rented a lab in a building for start-up companies, claiming that you receive so much support from each other and the nearby university. There was a lot of support between companies, but the rent was far too high for a very limited lab table and workplace. This is when Marian got out her laptop to look at rent prices! That's how help for starters looks! We kept an eye out for new premises and this way we caught sight of this building, near the HAS in Den Bosch. We now pay the same rent for a whole floor as we did for the lab and work place, and if the other tenant leaves the property, we hope to take that floor. The municipality supports us and we also benefit greatly from the HAS. They have the Insectlab, developing knowledge in the field of cultivation and we pay a lot of attention in the research, and in return we provide internships as a company.

Which insects are candidates for industrial production?

To answer this question, we go to the nearby HAS. At this point I would like to introduce Arjan Borghuis, Wageningen entomologist and HAS lecturer for the past 5 years (Figure 6). He enthusiastically explains that the university has dedicated a lot of space for the development of insect production systems. "For a year and a half I have had this new, small but well-equipped lab for insects and to experiment. Other departments of the HAS also look at insects, such as food processing (Food Technology, Animal and Livestock, International Food & Agribusiness). So far, we have carried out thirty projects for various companies such as Fransen Gerrits, a producer of pigs / chickens / piglets, the Voergroep Zuid (feed for all kinds of nutrition animals) and Protix from Dongen. In these thirty projects, other projects in the field of food and feed processing have not been counted yet!"

Protix from Dongen (4) is a company that wants to keep an eye on members of the NGvA, as they are already processing 32,000 tons of food every year into protein concentrates and pet food. The fats are used in piglets and chicken feeds, and in future feed for trout and aquarium fish. The residual current of the production is sold as a soil improver. Protix provides young larvae to insect farmers who produce 2,000 tonnes of larvae per unit per year, which is usually produced in converted pig stalls (5).

In large scale insect production, parasites and diseases can be expected to play a role. In the InsectLab, I meet two students who investigate whether a mite that is a parasite for flour worms can be combated with a commercially available predatory mite (*Thripex van Koppert*, see Figure 7). The solution seems to be effective. Rothuis also states that earlier research has already taught that the accurate control of air humidity in the nursery room plays a key role in the control of mites.

But now back to the question: which are the most promising insects as a producer of raw material for livestock and fish feed? Borghuis still believes that the development in this area is too young to draw conclusions from. Each candidate has its specific advantages and disadvantages and no production system has been fully developed. The substrate for the culture has as much influence on the content and quality of proteins and fats as the selection of seeds. Different types of flies, at least their larvae, are promising because they grow fast on moist waste from the food industry. The feeds for "black soldier flies" (*Hermetia illucens* L.) are therefore seen as promising.

Are insects an alternative to fishmeal as an ingredient in feed?

Obviously, Vrij is very optimistic in her answer to this question and points to different tables and charts she has already shown during her presentation to the NGvA. She reiterates that the larvae of the silkworms can be added to fill additional protein requirements of koi carp, and have been sold for years for this purpose. But koi carp usually do not end up as a fillet in the fishmonger. Tran et al (6) and Henry et al (7) presented in 2015 comprehensive documented overviews of the available

information. In both articles, different types of insects and / or their meal are compared with soya meal and fish meal. Insects are very variable in terms of composition, if you look at species, stage of development and culture substrate. In terms of carbohydrate and protein composition and fish digestibility, the signals are predominantly green. The amino acid composition of fly larvae is close to that of fish meal. Although chitinase has been shown in the intestinal tract of various fish, chitin residues in insect meal appear to reduce digestibility. But chitin can be effectively removed and has good commercial value in purified form. The levels of saturated fats in insects (larvae) are significantly higher than those in fishmeal and that of the polyunsaturated fats are significantly lower to very low. Vrij: "The removal of fats also occurs in fishmeal, so that cannot be an insurmountable problem, and initially we could develop the first formulas for fish that can be well-tolerated. "Like Borghuis and Vrij, the said authors point out the possibility of increasing the unsaturated fatty acid content by feeding larvae to the fish processing industry (St Hilaire, 2007). Sealey et al. (8) fed the Black Soldier Flies on cow manure to which waste was added from a fish processor. The flies were then fed to rainbow trout. Both the taste and growth of the trout were very satisfying. It is clear that here there may be another technological bottleneck.

Conclusions

The world's population is rapidly growing to 9 billion people, all of whom need to be fed. Proteins are essential, but also unsaturated fats, vitamins and minerals. Although a vegetarian diet can largely meet dietary requirements, animals and especially fish will continue to play an important role in the nutrition of humans. Fishmeal and oil are still essential in the production of the most important commercial fish. The price of fishmeal and availability fluctuate strongly and as the aquaculture sector grows, demand will increase, while the catch cannot grow any further and therefore the price must rise. Moreover, aquaculture based on fishmeal from pelagic fish cannot be sustainable as suggested by Tacon and Metian (9) and Tacon and Hasan (10). Insects can be grown sustainably on waste streams from agricultural companies and the food industry. In addition, they can convert these residues into high quality proteins and fats. In whatever scenario the future holds, insects must be used in fish production.

The biggest bottleneck in the insect sector was the ban on the use of insects (protein) 2 years ago as raw material for the feed of fish and other production animals. That bottleneck appears to have largely disappeared, although insects still cannot be fed with waste products from the animal food chain. Clearly, as the next bottleneck, the scale of the production of the insect farmers is linked to the scale of production of food and non-food raw materials based on cultured insects, technology development and cost-reduction by volume effects and production efficiency.

Vrij and Peters are ready to put into practice the concepts that the company has developed and if everything goes well, the trial factory will be set up in approximately one year. In any event, ABN-AMRO draws a sunny perspective for investors in this young and small sector (11)

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