supplement insect based food products with oil soluble nutrients including essential fatty acids, such as the omega-3 fatty acids.

Due to the large capital investment associated with setting up a fish feed extrusion facility, a high break-even point of annual sales is required in order to justify the large capital investment. As a result, fish farmers in regions with no fish feed extrusion facilities are forced to rely on expensive feed imports.

Attempts to use invertebrate larvae as a source for aquaculture animal feed have been made. For example, U.S. Patent No. 6,303,175 discloses a gel-like feed for aquatic animals, especially fish, shrimps and invertebrates, in fresh and sea water, usable as replacement of frost feed for the nutrition of warm and cold water ornamental fish in an aquarium. The feed contains a gel former, natural feed source and water, and optionally further nutrient additives.

U.S. Application Publication No. 2004/0096543 discloses fish food comprising whole invertebrate organisms coated with a hydrocolloid suspension in aqueous phase, wherein hydrocolloid can be gelated.

U.S. Application Publication No. 20180000122 and U.S. Application Publication No. 20200221733 disclose micro-encapsulated aquaculture feed including an oil phase having an oil-soluble nutrient component; a water phase, which is present inside the oil phase, and which includes a water-soluble nutrient component; and a film, which includes the oil phase and the water phase. The water-soluble nutrient component includes at least one hydrolysate selected from hydrolysates of amino acids, oligopeptides, and proteins.

Presently, there is no solution for commercial production of complete insect-based fish food that does not include the refining and extraction of protein and fat from the insect as well as the capital-intensive and highly technical feed pellets extrusion process.

There is a need in the market for a sustainable, complete food for aquaculture-animal and methods of producing same, which may be available and affordable to the end users.

SUMMARY

The present disclosure provides a complete food product for aquatic animals,

particularly fish or crustaceans, tailor-made for the species of the aquatic animal, its stage of development and environmental growing conditions. The present disclosure further provides a platform technology for producing the complete food product that can be performed by an end user without the need of sophisticated equipment and/or significant investments.

The complete food of the present disclosure is based on intact or chopped insect larvae enriched with all nutrients such as amino acids, fatty acids, vitamins, minerals and additional functional ingredients required for the aquatic animal growth, development and health, and missing from the larvae natural body components. The complete food of the disclosure can be produced by an end user by coating larvae with the nutrient compositions of the disclosure at the site of use. The teachings of the present disclosure are thus advantageous over hitherto known aquatic animal feed and methods of producing same at least in that the final product provides the aquatic animal with all its nutritional requirements; it is appealing to the consuming animal; it has no or minimal hazardous effects on the environment; and is economical.

According to one aspect, the present disclosure provides a food for aquatic animals comprising at least one species of insect larvae or a part thereof coated with solid or semi solid coating comprising a nutrient composition, the nutrient composition comprising an oil phase and at least one nutrient component enriching the nutritive value of the larvae.

According to certain examples, the at least one nutrient component is selected from the group consisting of oil-soluble nutrient, water soluble nutrient and a combination thereof. According to certain examples, the nutrient composition further comprises a water phase.

According to certain exemplary examples, the nutrient composition further comprises at least one food grade functional material forming a water-stable film coating. According to these examples, the water-stable film coating at least partially encapsulates the insect larvae coated with the nutrient composition. The food grade functional material may interact with the oil phase to form the water-stable film coating or said material or a combination of said materials may form the water-stable film coating.

According to certain examples, the food grade functional material forming a water-stable film coating prevents leaching of the nutrient components and optionally

further stabilizes the formulation of the nutrient composition. The functional material forming the film coating can be selected from a wax, an emulsifier, a polysaccharide, a protein, a resin and combinations thereof.

According to certain examples, the functional material forming the film coating is a wax, an emulsifier or a combination thereof.

In certain examples, the wax is a hard wax. In additional examples, the emulsifier is a solid emulsifier.

According to certain examples, the larvae are of a species selected from the group consisting of Black Soldier Fly (*Hermetia Illucens*), Common Housefly (*Musca domestica*), Yellow Mealworm (*Tenebrio molitor*), Lesser Mealworm (*Alphitobius diaperinus*), House Cricket (*Acheta domesticus*), Banded Cricket (*Gryllodes sigillatus*) Field Cricket (*Gryllus assimilis*) or any other suitable insect species, and any combination thereof.

According to certain examples, the oil-soluble nutrient component is selected from the group consisting of a fatty acid, an oil-soluble vitamin, an oil-soluble nutritional mineral and any combination thereof.

According to certain exemplary examples, the fatty acid is selected from the group consisting of Eicosapentaenoic acid (EPA, omega 3), Docosahexaenoic acid (DHA, omega 3), and a combination thereof. It is to be explicitly understood that the fatty acid may be a component of the oil used to form the oil phase of the nutrient composition or it may be separately added to the nutrient composition.

According to certain exemplary examples, the oil-soluble vitamin is selected from the group consisting of vitamin E, vitamin K, vitamin D, vitamin A, and any combination thereof.

According to certain examples, the water-soluble component is selected from the group consisting of an amino acid, a water-soluble vitamin, a water soluble nutritional mineral and any combination thereof.

According to certain examples, the nutrient composition further comprises at least one aquatic-animal compatible ingredient selected from the group consisting of a palatability enhancer, a pigment, a preservative, an anti-oxidant and any combination

thereof.

According to certain examples, the nutrient composition further comprises at least one aquatic-animal compatible medication.

According to certain examples, the nutrient composition further comprises at least one aquatic-animal compatible vaccine.

According to certain examples, the larvae are in a form selected from a live form and a dead form. According to certain examples, the dead larvae are partially or completely dried.

According to certain examples, the components of the nutrient composition and their ratios are set according to the aquatic animal species and/or growth stage.

According to yet additional aspect, the present disclosure provides a process for preparing a food for aquatic animal comprising at least one species of insect larvae, comprising:

a. obtaining at least one species of larvae separated from the larvae frass and/or any residual rearing substrate; and

b. coating the larvae with a solid or semi solid nutrient composition comprising an oil phase comprising at least one nutrient component, and optionally a water phase.

The oil phase and nutrient components are as described hereinabove.

According to certain examples, said process further comprising adding at least one food grade functional material to form a water-stable film coating at least partially encapsulating the coated larvae.

According to certain examples, the larvae are obtained at a growth stage set by the chitin content of said larvae, wherein said chitin content is suitable for the aquatic animal to be fed.

According to certain examples, the process further comprises analyzing the nutritional content of the larvae. Analyzing the nutritional content of the larvae assists in setting the nutritional components to be added to the food, taking in account the species, size, and developmental stage of the aquatic animal to be fed.

According to certain examples, the step of obtaining the larvae comprises chopping or otherwise dividing the larvae to smaller parts.

According to certain examples, the process further comprises a step of sanitizing the obtained larvae to minimize the presence of pathogens on said larvae.

According to certain examples, the process further comprises drying the larvae. The larvae can be partially or completely dried.

According to certain examples, the process includes a pre-treatment of the larvae prior to coating that aims at enabling easier digestion of the larvae by certain species of aquatic animals. According to certain examples, the pre-retreatment comprises at least one of reducing the amount of chitin in the larvae, softening the larvae cuticle, and/or reducing the cuticle thickness without reducing the chitin content. The above-described pre-treatments can be performed by any method as is known in the Art.

According to certain examples, the chitin content is reduced by applying certain acids such as citric acid and acetic acid or by applying alkali such as caustic soda. Softening the cuticle may be achieved by heat treatment such as by applying hot air, steam, or hot water or by heating with microwave energy; by subjecting the larvae to cuticle softening enzymes; or by subjecting the larvae to microbial fermentation.

According to certain examples, the process further comprises drying the coated larvae.

According to yet additional aspect, the present disclosure provides a method of feeding an aquatic animal, the method comprising providing to the aquatic animal rearing water a nutritionally effective amount of the food as defined herein.

According to certain examples, the present disclosure provides a method of feeding an aquatic animal, the method comprises applying to the rearing water of the aquatic animal a nutritionally effective amount of the food of the present disclosure. The nutritionally effective amount will be set according to the aquatic animal species, size, developmental stage etc. as is known to a person skilled in the Art. According to some examples, the method comprises applying the food of the disclosure in combination with extruded feed pellets.

It is to be understood that any combination of each of the aspects and the examples disclosed herein is explicitly encompassed within the disclosure of the present disclosure.

Further examples and the full scope of applicability of the present disclosure will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred examples of the disclosure, are given by way of illustration only, since various changes and modifications within the spirit and scope of the disclosure will become apparent to those skilled in the Art from this detailed description.

BRIEF DESCRIPTION OF THE FIGURES

FIG.1 is a schematic presentation of the encapsulated larvae.

FIG. 2 is a flow chart showing the production of the food of the invention comprising larvae coated with nutrient composition and use thereof.

FIG. 3 shows the reduction in feed conversion ratio (FCR) in Rainbow Trout fish fed with the food of the invention comprising larvae coated with nutrient composition.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides novel food for feeding aquaculture animals comprising whole or chopped invertebrate organisms, dead or alive, moist or dried, coated with an enrichment substance containing ingredients missing from the larvae body and required for optimal growth and health of aquaculture animals, particularly fish and crustaceans.

The terms “food” and “feed” are used herein interchangeably, and refer to a nutrition product or composition, particularly to nutrition product/composition suitable for feeding aquaculture animals.

Insect larvae, for example larvae of any one of Black Soldier Fly (*Hermetia Illucens*), Common Housefly (*Musca domestica*), Yellow Mealworm (*Tenebrio molitor*), Lesser Mealworm (*Alphitobius diaperinus*), House Cricket (*Acheta domesticus*), Banded Cricket (*Gryllodes sigillatus*) Field Cricket (*Gryllus assimilis*) may be used as food for aquaculture animals, particularly fish. While known as a good protein source, the larva body does not contain all the ingredients required for an optimal growth and development, including reproduction, of aquatic animals.