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Anti-nutritional factors in plant-derived feed ingredients and their reduction strategies

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Abstract

In order to lessen reliance on fishmeal, plant-derived feed ingredients are being studied as a potential substitute protein source in aquaculture. These plant-derived compounds typically comprise antinutritional agents such phytase, tannins, saponins, protease inhibitors, and trypsin inhibitors, which have a negative impact on nutrient utilization, growth performance, and the health of cultured species. Antinutritional factors combined with nutrients are a major source of concern because they reduced nutrient bioavailability in cultured species, resulting in micronutrient malnutrition and mineral shortage. Effective management of ANFs is therefore essential for ensuring sustainable and cost-effective plant-based aquafeed compositions. To lower the antinutrient content in plant-derived feed ingredients, several processing procedures and processes are utilized, including fermentation, germination, autoclaving, and soaking.

Keywords : Antinutritional factor (ANFs), Plant-derived nutritional substances, Aquaculture

Introduction

Plant protein sources have been used in the feed industry for a number of reasons, including sustainability, availability, and cost-effectiveness. Plants contain thousands of chemicals that, depending on the situation, might be beneficial or harmful to organisms that consume them. They are utilized fresh and raw, dried, powdered, boiled, fermented, concentrated, and so on. It is fed directly to herbivorous fish and as a supplement or partial replacement for fish meal in fish feed formulations. Plant sources are characterized as alternatives that can be employed in fish feed without affecting its nutritional quality. Plant-based fish feed has disadvantages due to poor protein content and certain anti-nutrients (Mondal and Payra, 2015). Legumes, ferns, and other non-traditional animal feed sources have anti-nutritional properties in both their green and dry stages.

Antinutritional factors

Antinutritional factors are compounds that disrupt food use, growth, health, and reproduction in animals, either directly or through bio-transformation. Animals are susceptible to antinutritional influences, which have a negative impact on growth and health. Most antinutrients used in fish feed have poor physiological effects, stunted growth, and health difficulties, rather than causing mortality. Hypoglycemia, liver damage, pancreatic hypertrophy, and other pathological illnesses are linked to poor food conversion efficiency. The severity of these symptoms varies based on the amount of antinutrients consumed, animal species, size, age, and other physiological factors.

Antinutritional factors can be broadly classified into the following groups:

(a) Those affecting protein digestion such as protease inhibitors, lectins, tannins etc.

(b) Those affecting mineral utilization such as phytates, oxalates etc.

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(c) The antivitamins (amthamines, antiriboflavins etc.) that have an impact on vitamin use.

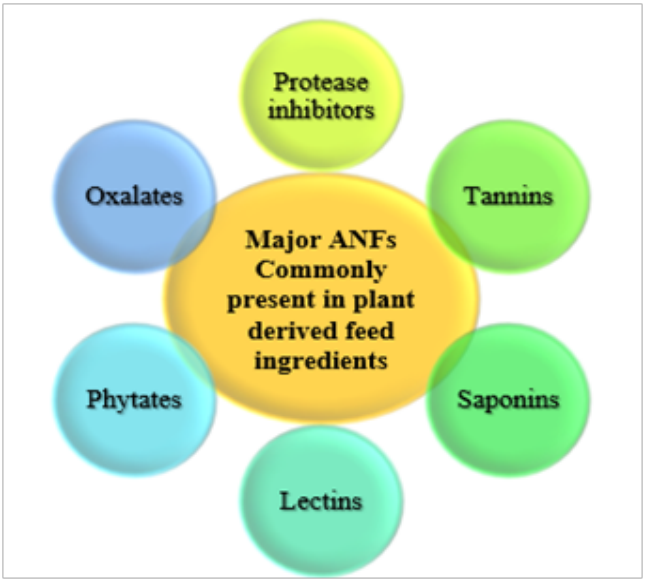
(d) Other miscellaneous compounds, such as mycotoxins, phytoestrogens, saponins, etc.

Antinutritional factors can also be grouped according to their ability to withstand thermal processing, the most commonly known treatment for destroying them.

(a) Thermolabile (heat-sensitive): Reduced or inactivated by cooking, extrusion, roasting, or autoclaving. e.g., enzyme inhibitors, Lectins and certain alkaloids.

(b) Heat-resistant/thermostable: Dose not inactive by typical cooking or feed processing temperatures. e.g., Non-starch polysaccharides, phytic acid, saponins, and tannins

Major ANFs commonly present in plant-derived feed ingredients



Saponin : Saponins are widely distributed in nature, primarily in plants, and are generally regarded as non-volatile, surface-active secondary metabolites. Saponins are sugar-containing steroids or triterpenes. Many plant species, such as groundnuts, lupins, oil seeds, etc., naturally produce them as glycosides or triterpenes that produce foam.

Phytates : Phytates or phytic acids occur naturally in the plant kingdom. Phytic acid is a secondary compound that is typically present in all plant-based meals and naturally concentrates in plant seeds, particularly in legumes, peanuts, cereals, and oilseeds.

Tannins : Tannins are secondary chemicals found in plant leaves, fruits, and bark. Tannins generate reversible and irreversible tannin-protein complexes between their hydroxyl group and the carbonyl group of proteins, reducing protein digestibility and critical amino acid levels. Tannins interact with proteins, inactivating digestive enzymes and reducing protein digestibility.

Protease inhibitors : These chemicals can inhibit enzymes from performing proteolytic functions. They can be found in all plants, but are particularly common in legumes such as soybeans. These inhibitors attach to digestive enzymes such as chymotrypsin and trypsin, rendering them partially or completely inert.

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Lectins or Hemagglutinins : These are proteins that have a high affinity for sugar molecules. The name refers to the agglutination of red blood corpuscles (RBCs). Hemagglutinins can be found in seeds of higher plants. They continue to be present in Plant saps and tubers. Lectins reduce nutrition absorption from the gut or alimentary canal. These chemicals can cause internal hemorrhages. They also reduce growth.

Oxalates : Oxalates in feed ingredients can prevent fish from absorbing certain nutrients. For example, certain critical minerals, such as calcium, which is required for bone formation, a number of metabolic activities, and the cofactor requirements of multiple enzymes, have low bioavailability.

Strategies used to reduce ANFs levels in plant-derived feed ingredients

Various traditional and technical processes, including soaking, milling, roasting, boiling, germination, and fermentation, have been used to reduce anti-nutritional components in food. This article discusses processing methods for reducing phytate, tannin, and saponin concentrations in foods.

Milling : Milling is the most traditional process for separating the bran layer from the grains. This is the process of grinding grains into flour. Milling eliminates anti-nutrients from grain bran, including phytic acid, lectins, and tannins.

Soaking : In this procedure, plant materials are soaked in water to remove water-soluble ANFs (tannins, phytates) that diffuse into the medium. Soaking increased phytase activity, reduced grain phytate content, decreased phytochemicals, and drained water-soluble vitamins and minerals from grains and legumes. Soaking improves nutritional availability and digestion. It is a simple, low-cost pretreatment procedure with variable effectiveness.

Heat treatments : heat treatment reduces ANFs in plant feed ingredients by Inactivating heat liable ANFs such as protease inhibitors and lectins by unfolding the protein structure. It includes boiling, autoclaving, pressure cooking, extrusion cooking, and toasting.

Cooking or boiling at 100 ℃ for 60 minutes was enough to inactivate over 90% of the trypsin inhibitor activity in food.

Autoclave for 30 minutes at 125 ℃ and 15 Ib pressure to remove thermolabile inhibitory compounds (saponins, terpenoids, alkaloids).

Germination: In this approach, whole grams are soaked overnight and then knotted in a loose cotton cloth after being removed from the water. Seed germination activates phytase, which degrades phytate and reduces phytic acid concentration in the sample. Germination alters the nutritional content, biochemical properties, and physical characteristics of foods. This approach is widely used to reduce the anti-nutritional content of cereals

Fermentation : Fermentation is a microbial process in which microorganisms (bacteria, fungus, or yeast) create enzymes that convert ANFs to non-toxic, edible forms. Furthermore, this improves nutrient availability, feed efficiency, and promotes fish growth and health.

Conclusion : Plant-based feed ingredients are essential for sustainable aquaculture, however antinutritional

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factors may significantly affect nutrient uptake, growth performance, and fish health. A detailed understanding of their mechanisms and species-specific impacts, together with appropriate mitigation techniques, enables the creation of nutritionally efficient, cost-effective, and environmentally sustainable aquaculture feed.

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