Yucca schidigera in Aquaculture

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In modern aquaculture systems, farmers are increasing the stocking capacity of aquatic organisms to develop the yield and maximize water resources utilization. However, the accumulation of ammonia in fishponds regularly occurs in intensive aquaculture systems, resulting in reduced growth rates and poor health conditions. The inclusion of yucca extract is recognized as a practical solution for adsorbing the waterborne ammonia. Yucca has abundant amounts of polyphenolics, steroidal saponins, and resveratrol and can be used as a solution or as a powder.

Keywords: Yucca schidigera ; Aquaculture ; Sustainability ; Blue growth ; Water quality

1. Introduction

With the recent global environmental changes (e.g., global warming and pandemics), the necessity to produce organic and healthy food for humanity [1], and the need to reach food sustainability objectives that focus on finding alternative food sources with feasible and applicable practices [2], tremendous efforts are requested from primary animal protein producers (poultry, livestock, and aquaculture sectors) to guarantee sufficient protein amounts at low cost [3]. Recently, food security agencies have called for limiting the usage of antibiotics and chemotherapies in poultry, livestock, and aquaculture production due to their negative impact on natural immunity, either in the animals or the human body and their hazardous environmental risks [4][5][6]. Therefore, using natural alternative substances that act as growth promotors, immunostimulants, and antioxidative agents is urgently needed [7]. Medicinal herbs and their extracts are successfully applied as feasible and environmentally friendly products in the animal nutrition field [8].

Yucca schidigera and its extracts are among the medicinal plants associated with plenty of beneficial effects when applied in aquaculture [9]. Several studies found that aquatic animals' performances showed improvements as a direct result of using yucca as feed or water additives [10][11][12][13][14]. Dietary yucca increases protein metabolism in the fish body, with a possible reduction in ammonia excretion [9]. The improvement in protein metabolism enhances feed utilization and results in a high feed intake and growth rate [15]. Therefore, using dietary yucca results in improving the health condition, immune, and antioxidative responses of aquatic organisms [16]. Yucca plant originates from the deserts of the Southwestern United States and Mexico, which is known for their high temperature, lack of water, and stressful conditions [10]. Concurrently, yucca is characterized by its anti-stressor potential and beneficial effects that make it a prospective phytogenic additive for the aquaculture industry [12][17]. Yucca has abundant amounts of saponin and resveratrol, which can eliminate the waterborne ammonia and lower its impacts on aquatic animals' performance and health [18]. Therefore, many commercial aquatic products include yucca and saponin in their formulation to be applied in aquaculture ponds and intensive systems. It enhances the water quality, feed intake, growth rate, anti-oxidative, and immune responses in aquatic species. Furthermore, yucca increases resistance against infectious bacteria and invaders [13].

Recently, aquaculture activity has become massively developed and a safe and unique choice to produce cheap and nutritious seafood products as animal protein sources [19][20]. In this regard, intensive systems are applied to produce the maximum possible amounts of aquatic biomass per unit of water resources [21]. Nevertheless, the intensification of production induces side effects on aquatic animals' performances due to the high stocking capacity, ammonia emissions, leftover feed, lack of dissolved oxygen, feces, and organic materials [20][22]. These stressful conditions reduce feed consumption, growth rate, immunity, and antioxidative responses, with possible opportunities for bacterial infection [23][24]. Several managerial efforts to enhance water quality are normally applied, including regular water exchange, injection with oxygen, using pedals, filtering water with mechanical and biological filters, and including some nitrifying microorganisms [25]. Additionally, functional herbal substances, such as feed or water additives, are strongly recommended as environmentally friendly additives [26][27].

2. The Nature, Sources, and Composition of Yucca

The Yucca genus comprises perennial nature woody flowering shrubs and trees with various sword-shaped leaves [28], belonging to the family Asparagaceae and subfamily Agavoideae [29], which encompasses about 49 species spread particularly in arid regions of the American South West and Mexico and mostly producing economic benefits, including ornamental, industrial, nutritional, and medical applications [10][30][31].

Yucca products (powder and juice) are commercially available, where they were approved in 1965 by the Food and Drug Administration (FDA) (21 CFR 172.510) and can be used as dietary additives or supplements due to their beneficial impacts on well-being, growth performance, nutrient utilization, the removal of fecal odors and ammonia, hydrogen sulfide, and some other hazardous volatile compounds in human and animal excreta [32][33]. The main constituents of yucca powder or extract (YE) are steroidal saponins, polysaccharides, and polyphenols, which possess antioxidant, anti-inflammatory, antiviral, antiprotozoal, antiplatelet, antimutagenic, anticancer, cholesterol reduction, and iNOS-expression-inhibiting activities [34].

Saponin (triterpenoid saponins) originated from Quillaja saponaria (Molina: widely found in Peru, Chile, and Bolivia) and differs from saponin with a yucca origin (steroidal saponins), and is mainly used as an adjuvant in veterinary vaccines [18]. Saponins are one of the phytochemical compounds in the yucca and Quillaja plants that consist of two parts: one is hydrophobic (a lipophilic nucleus, namely, the sapogenin) and the other is a hydrophilic carbohydrate side chain(s) or oligosaccharides, which explains the surfactant ability of these compounds [35][36]. Saponin binds with cholesterol in an insoluble compound that results from a lipophilic bond between the hydrophobic parts of saponins (sapogenin) and cholesterol (hydrophobic steroid or triterpenoid nucleus) in a stacked micellar aggregation, thus inhibiting the recycling of entero-hepatic cholesterol [36][37]. Saponins have a direct impact on the permeability of intestinal cells, as well as the gastro microbiota (antiprotozoal activity) by forming complexes with sterols (cholesterol) in cell membranes [38][39]. Yucca phenolic constituents include two stilbenes with antioxidant and anti-inflammatory potentials, where the first is yuccaol A, B, C, D, and E (trans-3,3’,5,5’-tetrahydroxy-4’-methoxystilbene) and the second is resveratrol (trans-3,4’,5 tetraxydroxystilbene) [34][40][41].

3. *Yucca schidigera* Usage for Healthy Aquatic Animals

An updated and exclusive collection of results about yucca’s beneficial effects as a phytogenic additive for clean aquaculture activity are presented. Yucca can clearly enhance the quality of rearing water by reducing ammonia emissions that result from aquatic organisms due to its potential as a medicinal herb. As a water remedy, yucca removes excess ammonia and reduces the water toxicity impacts on fish performances. The enhanced water quality clearly provides clean environmental conditions for aquatic organisms. Since aquatic organisms are known for their high sensitivity to environmental stressors, yucca’s application can be considered an active substance for the “blue clean aquaculture industry.” Additionally, yucca showed growth-promoting effects when included as a dietary additive, with possible feed utilization potential. The enhancement of feed digestion and nutrient absorption activates the local intestinal immunity, which leads to improved immunity and high resistance against infectious diseases. There are direct and indirect effects implicated for both axes involved in the aims of the present work: yucca can directly achieve improved water quality but immunity and growth may be indirectly affected. The review analyzed and reconsidered the published papers and presented their analyses and conclusions accordingly. The controlled aquaculture conditions were created to operate fish cultivation under strict veterinary and animal welfare regulations that were established after several decades of research and accumulated knowledge. Unfortunately, the ecosystem faces several environmental fluctuations (e.g., global warming and water pollution), which impact aquaculture requirements (e.g., water quality). Additionally, the controlled farming procedures are still not fully applied in several countries, especially the developing countries due to the lack of resources and technical experience; this motivates more investigative efforts toward sustaining aquaculture activity. The overall performances of aquatic organisms that were treated with yucca as a dietary additive or a water cleaner encourage performing further studies to prove its mode of action based on biochemical and biological techniques.

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