BIOACTIVE FEED INGREDIENTS USED IN AQUACULTURE : A REVIEW

ABSTRACT

Food security is a critical concern for nations like India, where poverty affects access to nutritious food for a significant portion of the population. While India has made strides in addressing this issue through agricultural revolutions, evolving demands necessitate a reformation in aquaculture practices. With a global surge in demand for fish and fisheries products due to their nutritional benefits, aquaculture has become pivotal. However, the intensification of aquaculture brings risks such as disease outbreaks and rising costs of essential feed ingredients like fish meal, particularly impacting the shrimp industry. To mitigate these challenges, exploring alternatives like bioactive feed additives sourced from marine and agricultural origins emerges as a promising solution. Marine derivatives such as algae offer nutritional benefits and bioactive compounds, while agri-industrial wastes provide versatile applications, including medicinal plant extracts and plant-based ingredients. Additionally, complex bioactive feed ingredients like probiotics, prebiotics, metabiotics, and phytobiotics show promise for enhancing the health and productivity of cultivated aquatic organisms. Integration of these alternatives into aquaculture practices presents a sustainable approach to improving food security, feeding efficiency, animal health and economic sustainability in India and beyond.

KEYWORDS: Bioactive feed, Marine derivatives, Agri-industrial derivatives, Prebiotic, Probiotic, Phytobiotic

1.0 INTRODUCTION

In the year 2023, a surprising 811 million people worldwide are still suffering from the scourge of hunger (Booking box, 2023). Almost three-quarters of a billion people are unable to exercise their right to adequate food as 2030 approaches and there are only seven years left to accomplish the Sustainable Development Goals (Index, 2023). In the face of these challenges, aquaculture, one of the fastest-growing businesses, emerges as a beacon of hope for tackling global food security issues (Booking box, 2023). Hunger and food insecurity are significant obstacles that young people must overcome during this crucial period in their lives (Index, 2023).

Food security is described as having a constant supply of secure and enough food for everyone (FAO, 2000). Food security is the primary approach for any country in the globe to improve its socioeconomic level and combat malnutrition. For developing nations like India, where the majority of the population lives in poverty and a portion of total family spending falls towards food, food security issues are of the utmost importance. India is being driven to provide food for its fast-increasing population through the green and blue revolutions (Pradeepkiran, 2019).

The increasing demand for global food production needs a fundamental restructuring of the aquaculture sector, as well as more efficient use of available resources and space (Boland et al., 2013). Furthermore, global demand for fish and fisheries products continues to increase due to several health benefits (Delgado et al., 2003; FAO, 2010). Fish and fishery products are recognized as excellent sources of protein and minerals (Tejpal et al., 2022). Aquaculture is one of the most resource-efficient and sustainable methods of producing animal protein. By 2030, the Food and Agriculture Organization estimates that 53% of the world's seafood supply will come from cultured aquatic species (Albrektsen et al., 2022).

Traditional intensive forms of aquaculture often contribute positively (Pradeepkiran, 2019). To meet current and future demand, the cultural sector accepted innovative intensive and super-intensive farming methods. Although fish production and productivity have increased due to enhanced farming, there is also a greater risk of disease outbreaks in the culture system, which can result in production and financial losses. As the sector has intensified, so has the demand for high-quality feed ingredients for feed formulation. Fish meal is a traditional aqua-feed ingredient, as well as the primary element in aqua feed, and its price has risen due to a lack of available fish for the manufacturing of the fish meal (Tejpaletal.,2022).

The shrimp industry uses 31% of all fish meal used in aquaculture and accounts for 16% of total aqua-feed production worldwide. The need for fish meal in the shrimp industry is expected to keep rising further until shrimp production doubles by 2030, resulting in a 90% increase in fish meal costs and a 70% increase in fish oil costs (Alune, 2021). Furthermore, India's aquaculture sector is experiencing a significant crisis due to a sudden increase in the cost of shrimp and fish feed due to the unexpected increase in the costs of the most important essential feed ingredients such as fish meal, soya meal, fish oil, and so on. As the cost of important feed materials such as fish meal rises, and expecting the negative effects of intensification in the culture system, look for alternatives such as bioactive feed additives. These bioactive substances contain functional qualities such as antioxidants, antimicrobials, growth promoters, and immune system modulators and are obtained from marine and agricultural sources (Tejpaletal., 2022). Bioactive compounds are compounds added to aqua-feeds that have the potential to improve feeding efficiency and reduce environmental impacts by improving animal health and lowering economic losses.

2.0 SOURCESOFBIOACTIVEFEEDINGREDIENTS

Most bioactive feed ingredients are isolated from marine derivatives and from agri-industrial wastes.

2.1 Marine Derivative Bioactive Feed Ingredients

One of the richest reservoirs of biomolecules is the marine environment, and these biomolecules have bioactive qualities like antioxidant, antimicrobial, antiviral, anti-parasitic, anti-inflammatory, anti-fibrotic, and anti cancer activity (Tejpaletal.,2022). Marine derivative bioactive feed ingredients are given below:

1. Seaweed and its derivatives
2. Fish protein hydrolysate
3. Chitin & Chitosan

2.2 Agri-IndustrialWasteBasedBioactiveFeedIngredients

Agricultural enterprises produce a lot of waste during the collection, storing, transferring, and processing of raw materials and can pollute the environment mostly because of organic matter; however, this organic matter is a source of bioactive compounds that are helpful for the aqua-feed industry (Nasrin & Matin, 2017). There are several bioactive substances present in agricultural residue. Bioactive substances can be found in any part of the plant, including the husk, seeds, leaves, roots, and stems (Veneziani et al., 2017). Agri-industrial waste contains following types of bioactive feed ingredients:

1. Plant-based bioactive feed ingredients
2. Herbal-based bioactive feed ingredients

2.3 Other Bioactive Feed Ingredients

Other than marine and agriculture waste, there are other sources that contains bioactive feed ingredients which given as follows:

1. Insect meal- based bioactive feed ingredients
2. Complex bioactive feed ingredients
3. Commercially available bioactive feed ingredients

3.0 MARINEDERIVATIVEBIOACTIVEFEEDINGREDIENTS

The marine environment is recognized as a goldmine of bioactive compounds that have good potential as a source of food components (Ghosh et al., 2022). Marine bioactive compounds include seaweeds, fish protein hydrolysate, chitin, and chitosan contain an excellent resource of bioactive ingredients.

3.1 Seaweed and its derivative-based bioactive feed ingredients

Algae are aquatic photosynthetic species that form the building blocks of the food chain. According to their size, it is divided into two major groups: microalgae and macroalgae (seaweeds). Many macro algal species have been used as ingredients in both medicinal and food preparations (Chandini et al., 2008). *Rhodophyta* (red),*Chlorophyta* (green),and *Phaeophyta* (brown) are the three taxonomic groups of seaweeds. They are used in nutritional studies as a primary feed ingredient and are regarded as boosting "standard" feed formulations rather than being a necessary source of fish feed (Ismail, 2019). As a source of essential amino acids, advantageous polysaccharides, fatty acids, antioxidants, vitamins, and minerals, marine macroalgae have been utilized as a nutritious feed supplement (Guedes et al., 2015; Ismail et al., 2017). In addition to being rich in nutrition, seaweed has bioactive chemicals that are antimicrobial, antiviral, antioxidative, anti-inflammatory, and neuro protective. These properties have been shown to enhance immune response, increase stress tolerance, and scavenge reactive oxygen species, or "ROS" (Prabu et al., 2016).

Seaweeds are distributed in supratidal, intertidal and subtidal horizontally (Stephenson & Stephenson, 1949). In intertidal zone green seaweeds are found viz. *Ulva* (sea lettuce), *Enteromorpha* (green string lettuce), *Chaetomorpha, Codium,* and *Caulerpa*. In the tidal or upper subtidal zone, brown seaweed inhibits for example *Sargassum, Laminaria, Turbinaria*, and *Dictyota*. In subtidal water red seaweeds grow viz. *Gracilaria, Gelidiella, Eucheuma, Ceramium,* and *Acanthophora*. Blue-green algae grow in a supra-tidal zone as colonies (Chapman, 1980; Dawson, 1966; Levring et al., 1969; Rao et al., 2018). The complex polysaccharides known as phycocolloids are a highly interesting category found in the cell walls of several seaweeds, also the three most significant phycocolloids are carrageenan, algin and agar (Rao et al., 2018).

Agar is a vital phycocolloid derived from red seaweeds (Rao et al., 2018). The species that used to produce agar are *Gelidium, Gracilaria, Gelidiell aacerosa, Pterocladia capillaca, Pterocladia lucida, Ahenpeltia plicata, Acanthopheltis japonica, Ceramium hypnoides,* and *Ceramium boydenii* (Levring et al., 1969; Mc Hugh, 2003). Due to its structure, rheological behavior, stability and interactions, the algal polysaccharide agar has been employed for along time as a food binder. These features enable to making of firm, round, disk-shaped pellets that can be utilized in recirculating sea urchin rearing systems (Fabbrocini et al., 2011).

Another highly significant polysaccharide that is isolated from brown seaweeds, such as *Laminaria*, *Macrocystis*, *Sargassum* and *Ascophyllum*, is alginate (Raoetal., 2018). Alginate-producing seaweeds in India include *Sargassum, Turbinaria*, *Dictyota*, *Padina*, *Cystoseira, Hormophysa*, *Colpomenia*, *Spatoglossum*, and *Stoecospermum*, with *Sargassum* and *Turbinaria* serving as raw materials for the commercial synthesis of alginate (Kaliaperumal, 2006; Thirupathi & Rao, 2004). The linear polysaccharide sodium alginate ($NaC_6H_7O_6$) is derived from alginic acid and contains the amino acids1,4-d-mannuronic (M) and lguluronic (G). Alginate is a structural element of the cell wall of marine brown algae and the cell wall of brown algae contains approximately 30 to 60% alginic acid (dos Santos, 2017). It also contains antibacterial, antiviral, antimicrobial, and antifungal properties (Ngo& Kim, 2013; Lee et al., 2011). Sodium alginate is a common feed additive in aquaculture, especially for herbivorous and omnivorous fish species. It has been established that fish LMWSA diets can enhance growth performance, innate immunity, and disease resistance in tilapia against *S. agalactiae* (Van Doan et al., 2016). The immune stimulatory effect of sodium alginate on the white shrimp *Litopenaeus vannamei* and its resistance against *Vibrio alginolyticus* was carried out by Cheng et al. (2004).

Carrageenan is a high molecular weight sulfated polysaccharide found in the cell wall of red seaweed. Carrageenan is primarily produced through aquaculture-based seaweed farming, with *Eucheuma* and *Kappaphycus* species accounting for more than 90% of global carrageenan production (Rupert et al., 2022). Carrageenan has many bioactive applications such as an antioxidant, antibacterial, antiviral, antitumor, anticoagulant, anti hyper lipidemic and immune modulatory agent (Wang et al., 2017; Pacheco-Quito et al., 2020). Carrageenan supplementation of shrimp feed can improve innate immunity as well as the expression of immune-related genes in *Litopenaeus vannamei* (Dhewang et al., 2023).

3.2 Fish protein hydrolysate

Fish protein hydrolysate (FPH) is the enzymatic hydrolysis of protein into smaller peptides and free amino acids, which has recently captured considerable attention as a supplementary ingredient in the aqua-feed industry sector (Suma et al., 2023). Fish protein hydrolysate contains a very rich amount of soluble protein, making it more digestible and absorbable in comparison with whole protein (Abraha et al., 2017; Irianto & Fawzya, 2018). Short-chain peptides improve feed palatability, resulting in high feed utilization. Moreover, FPH contain high antioxidant peptides, which may protect fatty acid from peroxidation, enhancing the growth and health of cultured animals (Siddik et al., 2018).

Fish protein hydrolysates are used as a supplement or as a component in fish feed to replace fishmeal. Functional characteristics of fish protein hydrolysate include antihypertensive, antithrombotic, immunological modulatory, and antioxidative effects. The results of a study on the use of two types of fish protein hydrolysate (FPH) in place of fish meal in feed for post-larval shrimp, *Litopenaeus vannamei*, showed that FPH may be used to replace fish meal and also promote the shrimp's growth (Quinto etal.,2018). In another study into the use of fish protein hydrolysate as a feed component for silver pompano (*Trachinotus blochii*) fingerlings, researchers discovered that the dietary supplement of FPH showed promising results in terms of enhancing growth, metabolism, immune response and resistance to bacterial infection (Tejpal et al., 2021).

3.3 Chitin& Chitosan

Chitin and chitosan, carbohydrate polymers found in crustacean waste, offer diverse applications, including their use as additives in fish and shrimp feeds. Additionally, crustacean waste contains valuable carotenoids, which can be extracted from chitosan and utilized as additives in aquaculture and ornamental fish feeds, enhancing color intensity. The inclusion in fish feed formulations improves digestibility, growth, and nutrient absorption. Chitosan would be a good immune stimulant/ growth promoter in shrimp diets (Andriani et al., 2023).

It has been demonstrated that chitin and the deacetylated derivative of chitin, chitosan, have positive effects on the performance of cultured fish and are therefore regarded as functional components or bioactive substances (Abdel-Ghany & Salem, 2019; Alishahi & Aider, 2011). Chitin and chitosan supplementation in the diet increases growth rates, feed efficiencies and disease resistance in several fish species, including rainbow trout (*Oncorhynchus mykiss*), Nile tilapia (*Oreochromis niloticus*), grey mullet (*Lizaramada*) red sea bream (*Pagrus major*), Japanese eel (*Anguilla japonica*), and yellowtail (*Seriola quinqueradiata*) (Ahmed et al., 2021; Dawood et al., 2020; Elserafy et al., 2021; Kono et al., 1987; Qin et al., 2014; Shi et al., 2020).

4.0 AGRI-INDUSTRIAL WASTE-BASED BIOACTIVE FEED INGREDIENTS

4.1 Plant-based bioactive feed ingredients

Plant active substances can be broadly divided into alkaloids, terpenoids (including triterpenes and steroid saponins), phenolic compounds, glycosides, flavonoids, tannins, and polysaccharidesbasedontheirchemicalstructures (Lovkova etal.,2001).The use of plants as bioactive feed in aquaculture shows antimicrobial/ immune-modulatory properties due to secondary metabolites of the above-mentioned classes of compounds (Bulfon et al., 2015). Various types of plant-based bioactive feed ingredients are used in aquaculture such as corn silk, banana peel, orange peel, mango peel, mushroom, grape seed extract, and olive waste cake.

Corn silk has traditionally been employed to treat cystitis, edema, gout, kidney stones, nephritis, and urological problems (Ebrahimzadeh et al., 2008). Corn silk is a good source of essential nutrients, including fibers, proteins, carbs, vitamins, and minerals (Ren et al., 2013). It also contains a variety of bioactive substances, including steroids, volatile oils, and other naturally occurring antioxidants including polyphenols and flavonoids (Hu & Deng, 2011; Bhuvaneshwari & Sivakami, 2015; Žilić et al., 2016). The immunostimulatory and antioxidative properties of corn silk from *Zea mays L.* in the Nile tilapia (*Oreochromis niloticus*) show that the dietary supplementation of corn silk extract lowered the level of lipid peroxidation in the liver of Nile tilapia under paracetamol-induced oxidative stress (Catap et al., 2015).

Banana peel is a food waste produced by households and businesses that can make upto 35% of the mature fruit (Emaga et al., 2008). The bioactive substances flavonoids, tannins, phlobatannins, alkaloids, glycosides, anthocyanins, and terpenoids present in banana peels have been discovered to have a variety of biological and pharmacological effects, including antibacterial, antihypertensive, antidiabetic, and anti-inflammatory effects (Pereira & Maraschin,2015).The dietary administration of banana peel powder can modulate the growth parameters, antioxidant status, immune responses, and expression of cytokine genes in *L. rohita*. Also banana peel can be used as a feed additive in aquaculture to improve fish growth and disease resistance (Giri et al., 2016).

One of the most popular tropical fruits, *Citrus sineresis* is an excellent source of antioxidants, vitamins and minerals (Moo-Huchin etal., 2015). Orange peel contains bioactive substances such as limonoids, enzymes, dietary fibers, carotenoids, and phenolic compounds (Boukroufa et al., 2015; Jokić et al., 2020; Obafaye & Omoba, 2018). These important components are also high in antioxidants, which have a wide range of health advantages, including the prevention of chronic diseases, the reduction of cancer incidence, and anti-inflammatory actions (Anticona et al., 2020; Meléndez-Martínez et al., 2022; Sagar et al., 2018). The dietary orange peels can act as a growth promoter and can improve the nutrient-absorptive ability of the intestine in Nile tilapia fingerlings (Salem &Abdel-Ghany, 2018).

Mango peel is a rich source of bioactive compounds that have potential health benefits. Mango peel includes antibacterial, anti-diabetic, anti-inflammatory, and anti- carcinogenic compounds such as protocatechuic acids, mangiferin, and -carotene (Lebaka et al., 2021). Mango peel is rich in beneficial substances such as polyphenols, carotenoids, enzymes, and dietary fiber (Ajila et al., 2007).

Numerous bioactive substances with anti-inflammatory, anti-acne, and anti-dermatitis effects have been found in grape seed extract. Additionally, grapeseed oil has several bioactive substances, such as carotenoids, phytosterols, phenolic acids, tocotrienols, and tocopherols (Gitea et al., 2023). Application of GSE as a dietary supplement in aquaculture can improve the growth performance, antioxidant status, and disease resistance in cultured organisms (Arslan etal., 2018; Lange et al., 2014; Zhai et al., 2014; Kao et al., 2010). According to Mehrinakhi et al., 2020, an extract of GS can enhance growth performance, humoral and mucosal immunity, and resistance against *Aeromonas hydrophilla* in Common carp.

Olive waste cake is the main by-product of the olive oil industry (Hoseinifar et al., 2020). Olive waste cake contains various types of bioactive compounds such as polyphenols which provide antioxidant and anti-inflammatory properties (Mertens-Talcott et al., 2006). Phenolic compounds include flavanols and flavonoids (Suárez et al., 2010). Hoseinifar et al. (2020) investigated the effects of dietary olive waste cake on performance, antioxidant condition, immune responses of rainbow trout (*Oncorhynchus mykiss*) and it can improve growth rate, oxidative stress status, humoral and skin mucosal immune responses.

Mushrooms are widely recognized for their bioactive components such as lectins, polysaccharides (β-glucans), polysaccharide-peptides, polysaccharide-protein complexes, lanostanoids, other terpenoids, alkaloids, sterols, phenolic structured compounds, which possess many biological and therapeutic qualities such as antibacterial, antioxidant, anti-inflammatory, anti-diabetic, anti-tumorous, antiviral, and anti-immuno-modulatory effects (Fogarasi et al., 2020; Ma et al., 2013; Nagy et al., 2017).

The diverse range of bioactive substances present in plant-based ingredients demonstrates their potential as effective and sustainable additions to aquaculture feeds, promoting the health, growth, and disease resistance of cultured organisms.

4.2 Herbal-based bioactive feed ingredients

The use of medicinal plant extracts in aquaculture for illness prevention, growth promotion and production is a unique development that has the potential to eliminate the need for antibiotics (Ahmad &Abdel-Tawwab, 2011; Bairwa et al., 2012). Bioactive compounds that are present in herbal plants can enhance the growth, innate immune response and disease resistance against harmful microorganisms in fish (Gabriel et al., 2015). Aquaculture uses a variety of herbal-based bioactive feed components, including ashwagandha, neem, tulsi, bitter weed, thyme seed, and aloe vera.

Aloe vera is a succulent, stemless herb that is extensively spread in tropical and subtropical regions (Gabriel et al., 2015). A. vera is thought to be the most popular and bioactive, containing over 70 biologically active chemicals (Mahdavi et al., 2013; Langmead et al., 2004). Aloe gel is rich in a variety of polysaccharides, vitamins, minerals, enzymes, salicylic acid, lignin, saponins, fatty acids, hormones and around 20 of the 22 essential amino acids that the human body needs (Surjushe et al.,2008; Adesuyi et al.,2012).Other than these, Aloe vera also contains bioactive characteristics such as antibacterial, antiseptic, anti-inflammatory, immune-modulatory effects, anti-oxidant, anti-cancerous properties, anti-mutagenic and anti-hypersensitivity, growth and gastro-intestinal promoting effects (Poorfarid et al., 2022; Nwaoguikpe et al., 2010; Stanić, 2007; Heidarieh et al., 2013;

Mahdavi et al., 2013). In order to improve common carp growth, aloe vera extract can be used in the diet as a growth promoter, appetite stimulator, tonic, and immune-stimulant (Mahdavi et al., 2013).

Thymus vulgaris, a medicinal herb, may have the capacity to reduce the adverse effects of aflatoxins in feed (Parsaei et al., 2016). *T. vulgaris* contains phenolic compounds that possess antioxidant activities (Parsaei et al., 2016). El-Nekeety et al. (2011) showed that *Thymus vulgaris* oil promotes innate and acquired immunity, hence increasing resistance to AFT- induced immunological suppression.

Indian medicinal plant Ashwagandha, *Withania somnifera* a time-honored Ayurvedic herbal immune booster, that is effective as an immune-modulatory agent in fish (Sharma et al., 2017; Svoboda, 1992; Ziauddin et al., 1996; Sivaram et al., 2004). Ashwagandha contains various bioactive characteristics such as anti-stress, anti-oxidant, rejuvenating, and immune modulatory (Singh et al., 1982; Bhattacharya et al., 1997; Venkataraghavan et al., 1980; Ziauddin et al., 1996). Sharma et al. (2017) suggested that the dietary supplement of Ashwagandha can improve the growth, haemato-biochemical response and disease resistance against *A. hydrophila* for *L. rohita* fingerlings.

Neem is utilized for a variety of purposes due to its immunological, anti-inflammation, and anti-ulcer characteristics (Shah et al., 2009; Talpur & Ikhwanuddin, 2013; Kaur et al., 2020). Neem tree has a variety of pharmacological qualities that strengthen antioxidant qualities and protect against several bacterial, viral, and fungal illnesses. The dietary leaf extract has improved the growth and health of rainbow trout in hatchery settings, making it a great nutritional supplement (Abidin et al., 2022).

One of the most valued and comprehensive medicinal plants, tulsi (*Ocimum sanctum*), has long been utilized in India to prepare traditional medicines due to its medicinal significance (Raghav & Saini, 2018). The Tulsi leaf extract contains eugenol, urosolic acid, carvacrol, rosmarinic acid, α & β-caryophyllene, linalool, euginal, β-elemene, geraneol and oc-imene as its main active ingredients (Ahmed et al., 2002). Other than these active ingredients, it also has antimicrobial, antibacterial, antifungal, antiviral, and antioxidant properties (Raghav & Saini, 2018). Tulsi leaf extract can stimulate immunity and make *L. rohita* more resistant to bacterial infection of *A. hydrophila* (Das et al., 2015).

The incorporation of medicinal plant extracts, such as Aloe vera, Thymus vulgaris, Ashwagandha, Neem, and Tulsi, into aquaculture practices represents a promising and sustainable approach to promoting fish health and growth. These herbal extracts offer a diverse range of bioactive compounds with proven immunomodulatory, antioxidant, and antibacterial properties. As alternatives to antibiotics, these plant-based supplements have the potential to enhance disease resistance, stimulate immune responses, and improve overall well-being in aquaculture, paving the way for a healthier and more environmentally friendly approach to fish farming.

5.0 OTHER BIOACTIVE FEED INGREDIENTS

5.1 Insect meal-based bioactive feed ingredients

Insect protein has received considerable scientific attention due to its high energy conversion efficiency, good nutritional quality and benefits in growth and health enhancement in fish and shellfish (Barroso et al., 2014; Henry et al., 2015; Xiao et al., 2018). Due to its richness in lipids, vitamins, minerals, and aminoacids (AAs), insect meal (IM) is becoming a more popular energy source for the agricultural industry (Premalatha et al.,2012). Insect-based diets that have immunomodulatory and physiological effects include four major groups, black soldier fly (*Hermetia illucens*), yellow mealworm (*Tenebrio molitor*), housefly (*Musca domestica*), silkworm (*Bombyx mori*), and a minor group of insect species such as locusts, grasshoppers, termites, crickets, and beetles (Mousavi et al., 2020).

Black soldier fly (*Hermetia illucens L.*) Is one of the most attractive sources for its sustainability as an unusual protein source for fish feeding due to its ability to transform organic waste material into biomass-containing proteins (40-45%) with high biological value (Comment et al.,2007). Also, there was a wide range of antibacterial activity in the BSF larval extract (Veldkamp et al., 2022). Dietary addition of BSF extract could stimulate immune competence hematological measures in common carp (*C. carpio*) challenged with *A. hydrophila* (Nurin & Maftuch, 2018).

The yellow mealworm (*Tenebrio molitor* (TM)) is one of the few unique options for potential FM replacement in aqua feeds (Iaconisi et al., 2017). *T. molitor* larvae and pupae have a high protein and lipid content because they contain many essential amino acids (EAAs)(particularly methionine), lipids and essential fatty acids (EFAs), which vary depending on the worm's developmental stage (Ghaly & Alkoaik, 2009; Shafique et al., 2021). According to Ido et al. (2019), Yellow mealworm (*Tenebrio molitor*) larvae are a promising alternative animal protein source that improves red seabream growth performance.

Insect meal, particularly silkworm meal, has been demonstrated to have immune-modulatory and physiological effects in aquatic species, making it a functional element capable of increasing immune-stimulatory effects in a variety of aquatic animals (The protein of silkworm pupae is high in phenylalanine, methionine, and valine, three important amino acids (Karthick et al., 2019). Silk worm meal, an insect-based diet, can be used in place of fish meal to enhance the biochemical composition and growth performance of Catla-rohu hybrids (Nandeesha et al., 1988).

The utilization of insect protein, particularly from sources such as black soldier fly, yellow mealworm, and silkworm, represents a promising and sustainable alternative in aquaculture nutrition. These insect-based diets offer high energy conversion efficiency, nutritional richness in lipids, vitamins, minerals and essential amino acids, contributing to the growth and health enhancement of fish and shellfish. Moreover, the immune-modulatory properties observed in certain insect meals such as black soldier fly larval extract and silkworm meal, highlight their potential to positively impact the immune response and physiological well-being of aquatic species, making them valuable components in the development of innovative and environmentally friendly aquafeeds.

5.2 Complex bioactive feed ingredients

The use of novel and effective probiotic-based immunostimulating preparations, prebiotics, metabiotics, and phytobiotics is thought to be a promising direction for the development of new complex feed additives for aquaculture enterprises to improve the health and productivity of cultivated hydrobionts (Ushakova et al., 2021).

Probiotics have been defined as "live microorganisms that, when administered in adequate amounts, confer a health benefit on the host" (Hill et al., 2014). Probiotics have several beneficial effects, including strengthening the immune system, increasing competition for binding sites, producing anti-microbial compounds and increasing competition for nutrients that shield the body from disease (Ushakova et al., 2021).The majority of probiotics used for aquatic animals come from the genera *Lacto bacillus* and *Carnobacterium* genus *Vibrio*, genus *Bacillus*, or genus *Pseudomonas*; *Bacillus* is one of these that is most frequently used in aquacultures (Kuebutornye et al., 2019).

A Prebiotic can be defined as "a substrate that is selectively utilized by host micro organisms conferring a health benefit "(Gibson et al., 2017). Prebiotics are non-microbial compounds that are neither digested nor absorbed in the intestine but generate favorable conditions for the establishment of healthy microbiota in the large intestine (Lamsal, 2012).

Metabiotics are defined as the structural components and physiologically active metabolites of probiotic microorganisms (Yang et al., 2015; Ardatskaya, 2015). These may be hormone-like compounds that resemble signalling molecules and are secreted by beneficial bacteria. They may influence metabolic, regulatory and behavioural responses that are directly linked to the activity of the body's microbiota, which may help restore normal physiological functions (Ardatskaya, 2015).

Phytobiotics are defined as physiologically active compounds produced by plants (Ardatskaya, 2015; Windisch & Kroismayr, 2007; Mohammadi & Kim, 2018). Prebiotics derived from plants are an important component of feed that promotes beneficial gut microorganisms (Ushakova et al., 2021).

New opportunities are emerging in the application of complex biotics produced by probiotic bacteria by solid-phase fermentation of phyto components. Solid-phase fermentation of plant substrates is utilized to acquire numerous physiologically active compounds, enriching phyto-raw materials with useful products of bacterial substrate destruction and specific probiotic metabolites. Probiotic formulations with phyto components are defined by increased biological activity as a result of the combination of the probiotic effect with the presence of metabolites, as well as the action of biologically active phytobiotic components (Ushakova et al., 2021).

ProStor (NTC BIO, LLC) is a probiotic composed of the solid-phase fermentation products of *B.subtilis V-8130, B.subtilis V-2984* and *B.subtilis V-4099* cultivated on beet root pulp (Juhas et al., 2005). The HerbaStor (NTC BIO, LLC) product, which contains the yeast autolysate, is an updated version of the ProStor formulation. Metabolites of the active complex of probiotic species *Bacillus* were obtained through solid-phase fermentation of phytocomponents—beet pulp in combination with medicinal plants—that underwent preliminary biological treatment, ensuring the availability of biologically active components (Ushakova et al., 2021).

5.3 Commercially available bioactive feed ingredients

MOTIV™ is a fermented maize protein concentration (CPC) prepared by enzymatically eliminating non-protein components from maize. CPC has significant quantities of methionine, lysine, and other important amino acids, and it has a small amount of starch or ash (Khalifa et al., 2018; Prayitno et al., 2022). The usage of feed containing bioactive protein ingredients (MOTIV™) can enhance the number of *L.vannamei* shrimp hemocytes, which can be utilized to signal the shrimp's immune system and health state (Prayitno et al., 2022).

YELAPROSECURE which is a specifically designed hydrolyzed yeast that offers highly digestible and functional nutrients that support animal performance, digestive care, and feed palatability while contributing to the feed protein balance (Igelinas, 2023). The natural microalgal product NOVASTA®EB15, which is rich in a staxanthin, is made up of crushed and spray-dried aplanospores from the green microalga *Haematococcus pluvialis* (*NOVASTA® EB15 - AstaReal - Knowde*, n.d.).

6.0 CONCLUSION

In conclusion, the challenges faced by India's aquaculture sector, particularly the rising costs of essential feed ingredients, necessitate a shift towards sustainable and cost-effective alternatives. The incorporation of bioactive feed additives derived from marine and agricultural sources, such as medicinal plant extracts and insect proteins, presents a promising solution. These alternatives not only offer nutritional richness but also possess immunomodulatory, antioxidant, and antibacterial properties that can enhance the overall health and disease resistance of cultured organisms. Furthermore, commercially available bioactive feed ingredients like MOTIV™, YELA PROSECURE, and NOVASTA® EB15 demonstrate the potential for innovative solutions in aqua feed formulations, contributing to improved immune responses, digestive care, and feed palatability. Embracing these alternatives not only addresses the economic challenges but also promotes a more sustainable and environmentally friendly approach to aquaculture.

7.0 REFERENCES

Abdel- Ghany, H. M., & Salem, M. E. (2019). Effects of dietary chitosan supplementation on farmed fish; a review. *Reviews in Aquaculture*, *12*(1), 438–452. https://doi.org/10.1111/raq.12326

Abidin,Z.U.,Hassan,H.U.,Masood,Z.,Azmat,H.,Paray,B.A.,Khan,W.,Shah,M.,Gulnaz, A., Ullah, A., Zulfiqar, T., & Siddique, M. a. M. (2022). Effect of dietary supplementation of Neem, *Azadirachta indica* leaf extracts on enhancing the growth performance, chemical composition and survival of rainbow trout, *Oncorhynchus mykiss*. *Saudi Journal of Biological Sciences*, *29*(4), 3075–3081. https://doi.org/10.1016/j.sjbs.2022.01.046

Abraha, B., Mahmmud, A., Samuel, M., Yhdego, W., Kibrom, S., & Habtom, W. (2017). Production of fish protein hydrolysate from silver catfish (*Arius thalassinus*). *MOJ Food Processing & Technology*, *5*(4), 328-335.

Adesuyi,A. O.,Awosanya, O.A.,Adaramola, F. B., & Omeonu,A. I. (2012). Nutritional and phytochemical screening of *Aloe barbadensis*. *Current Research of Journal Biological Science*, *4*(1), 4-9.

Ahmad, M., &Abdel- Tawwab, M. (2011). The use of caraway seed meal as a feed additive in fish diets: Growth performance, feed utilization, and whole-body composition of Nile tilapia, *Oreochromis niloticus (L.)* fingerlings. *Aquaculture*, *314*(1–4), 110–114. https://doi.org/10.1016/j.aquaculture.2011.01.030

Ahmed, F., Soliman, F. M.,Adly, M.A., Soliman, H., El-Matbouli, M., & Saleh, M. (2021). Dietary Chitosan Nanoparticles: Potential Role in Modulation of Rainbow Trout (*Oncorhynchus mykiss*) Antibacterial Defense and Intestinal Immunity against Enteric Redmouth Disease. *Marine Drugs*, *19*(2), 72. https://doi.org/10.3390/md19020072

Ahmed, M., Ahamed, R. N., Aladakatti, R. H., & Ghosesawar, M. (2002). Reversible anti-fertility effect ofbenzene extract of *Ocimum sanctum* leaves on sperm parameters and fructose content in rats. *Journal of Basic and Clinical Physiology and Pharmacology*, *13*(1), 51–60. https://doi.org/10.1515/jbcpp.2002.13.1.51

Ajila,C., Bhat, S. P., & Rao, U. P. (2007). Valuable components of raw and ripe peels from two Indian mango varieties. *Food Chemistry*, *102*(4), 1006–1011. https://doi.org/10.1016/j.foodchem.2006.06.036

Albrektsen,S., Kortet, R., Skov, P. V., Ytteborg, E., Gitlesen, S., Kleinegris, D., Mydland, L., Hansen, J. Ø., Lock, E., Mørkøre, T., James, P. S. B. R., Wang, X., Whitaker, R. D., Vang, B., Hatlen, B., Daneshvar, E., Bhatnagar, A., Jensen, L. B., & Øverland, M. (2022).Future feed resources in sustainable salmonid production: A review. *Reviews in Aquaculture*, *14*(4), 1790–1812. https://doi.org/10.1111/raq.12673

Alishahi, A., & Aïder, M. (2011). Applications of Chitosan in the Seafood Industry and Aquaculture: a review. *Food and Bioprocess Technology*, *5*(3), 817–830. https://doi.org/10.1007/s11947-011-0664-x

Alune. (2023, September 29). *Shrimp feeds of the future*. The Fish Site. https://thefishsite.com/articles/shrimp-feeds-of-the-future

Anal, A. K. (2017). Food processing by‐ products and their utilization: Introduction. *Food processing by‐ products and their utilization*, 1-10.

Andriani , Y., Pratama , R. I., & Hanidah , I. I. (2023). Chitosan Application in Aquatic Feed and Its Impact on Fish and Shrimp Productivity. Asian Journal of Biology,19(1),25 – 30. https://doi.org/10.9734/ajob/2023/v19i1355

Anticona, M., Blesa, J., Frígola, A., & Esteve, M. J. (2020). High Biological Value Compounds Extraction from Citrus Waste with Non-Conventional Methods. *Foods*, *9*(6), 811. https://doi.org/10.3390/foods9060811

Arabski, M., Węgierek-Ciuk,A., Czerwonka, G., Lankoff,A., & Kaca, W. (2012). Effects of Saponins against Clinical *E. coli* Strains and Eukaryotic Cell Line. *Journal of Biomedicine and Biotechnology*, *2012*, 1–6. https://doi.org/10.1155/2012/286216

Ardatskaya, M. D. (2015). Probiotics, prebiotics and metabiotics in the correction of intestinal microecological disorders. *Med Counc*, *13*, 94–99. https://doi.org/10.21518/2079-701X-2015-13-94-99

Arslan,G.,Sönmez,A.Y.,&K,T.Y.(2018).Effects of grape *Vitisvinifera* seed oil supplementation on growth, survival, fatty acid profiles, antioxidant contents and blood parameters in rainbow trout *Oncorhynchus mykiss*. *Aquaculture Research*, *49* (6), 2256– 2266. https://doi.org/10.1111/are.13686

Babahmad, R.A.,Aghraz,A., Boutafda,A., Papazoglou, E. G., Tarantilis, P.A., Kanakis, C. D., Hafidi, M., Ouhdouch, Y., Outzourhit, A., & Ouhammou, A. (2018). Chemical composition of essential oil of Jatropha curcas L. leaves and its antioxidant and anti microbial activities. *Industrial Crops and Products*, *121*, 405–410. https://doi.org/10.1016/j.indcrop.2018.05.030

Bairwa, M. K., Jakhar, J. K., Satyanarayana, Y., & Reddy, A. D. (2012). Animal and plant originated immunostimulants used in aquaculture. *Journal of Natural Product and Plant Resources*, *2*(3), 397-400.

Barroso, F. G., de Haro, C., Sánchez-Muros, M. J., Venegas, E., Martínez-Sánchez, A., & Pérez-Bañón, C. (2014). The potential of various insect species for use as food for fish. *Aquaculture*, *422*, 193-201.

Bhattacharya, S. K., Satyan, K. S., & Chakrabarti,A. (1997). Effect of Trasina, an Ayurvedic herbal formulation, on pancreatic islet superoxide dismutase activity in hyperglycaemic rats. *Indian journal of experimental biology*, *35*(3), 297-299.

Bhuvaneshwari, K., & Sivakami, S. (2015).Analysis of nutrients and phytochemicals content in corn silk (Zea mays). *Int. J. Sci. Res*, *78*(96), 2319-7064.

Boland, M. J., Rae, A. N., Vereijken, J., Meuwissen, M., Fischer, A. R., Van Boekel, M., Rutherfurd, S. M., Gruppen, H., Moughan, P. J., & Hendriks, W. (2013). The future supply of animal-derived protein for human consumption. *Trends in Food Science and Technology*, *29*(1), 62–73. https://doi.org/10.1016/j.tifs.2012.07.002

Boukroufa, M., Boutekedjiret, C., Petigny, L., Rakotomanomana, N., & Chemat, F. (2015). Bio-refinery of orange peels waste: A new concept based on integrated green and solvent free extraction processes using ultrasound and microwave techniques to obtain essential oil, polyphenols and pectin. *Ultrasonics sonochemistry*, *24*, 72-79.

Bookingbox. (2023, December 14). *EFishery: Revolutionizing Aquaculture to Combat Global Hunger*. https://www.linkedin.com/pulse/efishery-revolutionizing-aquaculture-combat-global-hunger-eweqf/

Bulfon, C., Volpatti, D., & Galeotti, M. (2015). Current research on the use of plant- derived products in farmed fish. *Aquaculture Research*, *46*(3), 513-551.

Catap, E. S., Jimenez, M. R. R., & Tumbali, M. P. B. (2015). Immunostimulatory and anti-oxidative properties of corn silk from Zea mays L. in Nile tilapia, Oreochromis niloticus. *International Journal of Fisheries and Aquaculture*, *7*(3), 30-36.

Chandini, S. K., Ganesan, P., & Bhaskar, N. (2008). In vitro antioxidant activities of three selected brown seaweeds of India. *Food chemistry*, *107*(2), 707-713.

Chapman, V. J. (1980). Seaweeds and their Uses. In *Springer eBooks*. https://doi.org/10.1007/978-94-009-5806-7

Cheng, W., Liu, C. H., Yeh, S. T., & Chen, J. C. (2004). The immune stimulatory effect of sodium alginate on the white shrimp *Litopenaeus vannamei* and its resistance against

Vibrio alginolyticus. *Fish & Shellfish Immunology*, *17*(1), 41-51.

Comment, A. P., Initiative, N. U. A. F., & Sheppard, D. C. (2007). Black Soldier Fly Prepupae A Compelling Alternative to Fish Meal and Fish Oil. *NOAA-USDA alternative Feeds initiative Report. 17pp*.

Das, R., Raman, R. P.,Saha, H., & Singh, R. (2015). Effect of Ocimum sanctum Linn.(Tulsi) extract on the immunity and survival of Labeo rohita (Hamilton) infected with Aeromonas hydrophila. *Aquaculture Research*, *46*(5), 1111-1121.

Dawood, M. A., Gewaily, M. S., Soliman, A. A., Shukry, M., Amer, A. A., Younis, E. M., & Fadl, S. E. (2020). Marine-derived chitosan nano particles improved the intestinal histo-morphometrical features in association with the health and immune response of grey mullet (*Liza ramada*). *Marine drugs*, *18*(12), 611.

Dawson, E. Y. (1966). Marine botany : an introduction. In *Holt, Rinehart and Winston eBooks*. http://ci.nii.ac.jp/ncid/BA04422685

Dekkers, E., Raghavan, S., Kristinsson, H. G., & Marshall, M. R. (2011). Oxidative stability of *Mahima hi*red muscle dipped in tilapia protein hydrolysates. *Food Chemistry*, *124*(2), 640–645. https://doi.org/10.1016/j.foodchem.2010.06.088

Dhewang, I. B., Yudiati, E., & Alghazeer, R. (2023). Supplementation of Carrageenan (*Kappaphycus alvarezii*) for Shrimp Diet to Improve Immune Response and Gene Expression of White Shrimp (*Litopenaeusvannamei*). *ILMUKELAUTAN: Indonesian Journal of Marine Sciences*, *28*(2).

dos Santos, L. L. (2017). Natural polymeric biomaterials: processing and properties. *Reference module in materials science and material engineering*, 1-6.

Ebrahimzadeh, M. A., Pourmorad, F., & Hafezi, S. (2008). Antioxidant activities of Iranian corn silk. *Turkish Journal of biology*, *32*(1), 43-49.

El-Nekeety, A. A., Mohamed, S. R., Hathout, A. S., Hassan, N. S., Aly, S. E., & Abdel-Wahhab, M. A. (2011). Antioxidant properties of Thymus vulgaris oil against aflatoxin-induce oxidative stress in male rats. *Toxicon*, *57*(7-8), 984-991.

Elserafy, S., HAbdel-Hameid, N. A., AAbdel-Salam, H., & M Dakrouni, A. (2021). Effect of shrimp waste extracted chitin on growth and some biochemical parameters of the Nile tilapia. *Egyptian Journal of Aquatic Biology and Fisheries*, *25*(1), 313-329.

Emaga, T. H., Ronkart, S. N., Robert, C., Wathelet, B., & Paquot, M. (2008). Characterisation of pectins extracted from banana peels (Musa AAA) under different conditions using an experimental design. *Food chemistry*, *108*(2), 463-471.

Espín, J. C., González-Sarrías, A., & Tomás-Barberán, F. A. (2017). The gut microbiota: A key factor in the therapeutic effects of (poly) phenols. *Biochemical pharmacology*, *139*, 82- 93.

Fabbrocini, A., Volpe, M. G., Di Stasio, M., D'Adamo, R., Maurizio, D., Coccia, E., & Paolucci, M. (2011). Agar-based pellets as feed for sea urchins (*Paracentrotus lividus*): rheological behaviour, digestive enzymes and gonad growth. *Aquaculture Research*, *43*(3), 321–331. https://doi.org/10.1111/j.1365-2109.2011.02831.x

FAO. (2010). FAOSTAT. *Food and Agriculture Organization of the United Nations.*

FAO. (2022). *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation*. Rome, FAO. 266p.

Ferreira, I. C., Martins, N., & Barros, L. (2017). Phenolic compounds and its bioavailability. In*Advances in food and nutrition research* (pp.1–44). https://doi.org/10.1016/bs.afnr.2016.12.004

Fogarasi, M., Diaconeasa, Z. M., Pop, C. R., Fogarasi, S., Semeniuc, C. A., Fărcaş, A. C., & Socaci, S.A. (2020). Elemental composition, antioxidant and antibacterial properties of some wild edible mushrooms from Romania. *Agronomy*, *10*(12), 1972.

Gabr, S., Nikles, S., Wenzig, E. M., Ardjomand-Woelkart, K., Hathout, R. M., El-Ahmady, S. H., Motaal, A. A., Singab, A. N. B., & Bauer, R. (2018). Characterization and optimization of phenolics extracts from Acacia species in relevance to their anti-inflammatory activity. *Biochemical Systematics and Ecology*, *78*, 21–30. https://doi.org/10.1016/j.bse.2018.03.001

Gabriel, N. N., Qiang, J., He, J.,Yu, X., Kpundeh, M. D., & Xu,P. (2015). DietaryAloe vera supplementation on growth performance, some haemato-biochemical parameters and disease resistance against Streptococcus iniae in tilapia (GIFT). *Fish & Shellfish Immunology*, *44*(2), 504–514. https://doi.org/10.1016/j.fsi.2015.03.002

Ghaly,A.E.,&Alkoaik,F.N.(2009).The yellow mealworm as a novel source of protein. *American Journal of Agricultural and Biological Sciences*, *4*(4), 319-331.

Ghosh, S., Sarkar, T., Pati, S., Kari, Z. A., Edinur, H. A., & Chakraborty, R. (2022). Novel bioactive compounds from marine sources as a tool for functional food development. *Frontiers in Marine Science*, *9*. https://doi.org/10.3389/fmars.2022.832957

Gibson,G.R.,Hutkins,R.,Sanders,M.E.,Prescott,S.L.,Reimer,R.A.,Salminen,S.J.,...& Reid, G.

(2017). Expert consensus document:The International Scientific Association for Probiotics and Prebiotics (ISAPP) consensus statement on the definition and scope of prebiotics. *Nature reviews Gastroenterology & hepatology*, *14*(8), 491-502.

Giri, S. S., Jun, J.W., Sukumaran,V., & Park, S. C. (2016). Dietary administration of banana (Musaacuminata) peel flour affects the growth, antioxidant status, cytokine responses, and disease susceptibility of rohu, Labeo rohita. *Journal of immunology research*, *2016*, 1-11.

Gitea, M. A., Bungau, S. G., Gitea, D., Pasca, B. M., Purza, A. L., & Radu, A.-F. (2023). Evaluation of the Phytochemistry–TherapeuticActivity Relationship for Grape Seeds Oil. *Life*, *13* (1), 178. MDPI AG. Retrieved from http://dx.doi.org/10.3390/life13010178

Guedes, A. C., Sousa-Pinto, I., & Malcata, F. X. (2015). Application of microalgae protein to aquafeed. In *Handbook of marine microalgae* (pp. 93-125). Academic Press.

Hassoun, A., & Çoban, Ö. E. (2017). Essential oils for antimicrobial and antioxidant applications in fish and other seafood products. *Trends in Food Science & Technology*, *68*, 26-36.

Heidarieh, M., Mirvaghefi, A. R., Sepahi, A., Sheikhzadeh, N., ALİSHAHBAZFAR, A., & Akbari, M. (2013). Effects of dietary Aloe vera on growth performance, skin and gastrointestine morphology in rainbow trout (Oncorhynchus mykiss).*Turkish Journal of Fisheries and Aquatic Sciences*, *13*(2).

Henry, M., Gasco, L., Piccolo, G., & Fountoulaki, E. (2015). Review on the use of insects in the diet of farmed fish: Past and future.*Animal Feed Science and Technology*,*203*, 1-22.

Hill, C., Guarner, F., Reid, G., Gibson, G. R., Merenstein, D. J., Pot, B., ... & Sanders, M. E. (2014).TheInternationalScientificAssociationforProbioticsandPrebioticsconsensus statement on the scope and appropriate use of the term probiotic. *Nature reviews Gastroenterology & hepatology*, *11*(8), 506-514.

Hoseinifar, S. H., Shakouri, M., Yousefi, S., VanDoan, H., Shafiei, S.,Yousefi, M., & Faggio, C. (2020). Humoral and skin mucosal immune parameters, intestinal immune related genes expression and antioxidant defense in rainbow trout (Oncorhynchus mykiss) fed olive (Olea europea L.) waste. *Fish & shellfish immunology*, *100*, 171-178.

Hu, Q. L., & Deng, Z. H. (2011). Protective effects of flavonoids from corn silk on oxidative stress induced by exhaustive exercise in mice. *African Journal of Biotechnology*, *10*(16), 3163-3167.

Iaconisi,V.,Marono,S.,Parisi,G.,Gasco,L.,Genovese,L.,Maricchiolo,G.,...&Piccolo,G. (2017). Dietary inclusion of Tenebrio molitor larvae meal: Effects on growth performance and final quality treats of black spot seabream (Pagellus bogaraveo). *Aquaculture*, *476*, 49-58.

Ido,A., Hashizume,A., Ohta,T.,Takahashi, T., Miura, C., & Miura,T. (2019). Replacement of fish meal by defatted yellow mealworm (Tenebrio molitor) larvae in diet improves growth performance and disease resistance in red seabream Pargus major). *Animals*, *9*(3), 100.

Igelinas. (2023, August 31). *Specifically designed functional hydrolyzed yeast: YELA PROSECURE Lallemand Animal Nutrition*. Lallemand Animal Nutrition. https://www.lallemandanimalnutrition.com/en/europe/products/yela-prosecure/

Index, G. H. (2023). 2023 Global Hunger Index: The Power of Youth in Shaping Food Systems.

Irianto,H.K.,&Fawzya,Y.N.(2018).FISH protein hydrolysates: Their potential application for prevention of stunting. *Med. Res. Innov*, *2*, 1-2.

Ismail, M. M. (2019). Review on seaweed as supplement fish feed. *Journal of Applied Phycology*, *30*(1), 619-628.

Ismail, M. M., El Zokm, G. M., & El-Sayed, A. A. M. (2017). Variation in biochemical constituents and master elements in common seaweeds from Alexandria Coast, Egypt, with special reference to their antioxidant activity and potential food uses: prospective equations. *Environmental monitoring and assessment*, *189*(12), 648. https://doi.org/10.1007/s10661-017-6366-8

Jokić, S., Molnar, M., Cikoš, A. M., Jakovljević, M., Šafranko, S., & Jerković, I. (2020). Separation of selected bioactive compounds from orange peel using the sequence of supercritical CO2 extraction and ultrasound solvent extraction: Optimization of limonene and hesperidin content. *Separation Science and Technology*,*55*(15), 2799-2811.

Juhas, M., Eberl, L., & Tümmler, B. (2005). Quorum sensing: the power of cooperation in the world of Pseudomonas. *Environmental microbiology*, *7*(4), 459-471.

Kaliaperumal, N (2006) Commercial cultivation of agar yielding red seaweed Gracilaria edulis. National workshop on seaweed farming and processing for food. Kilakarai, India. Pp 28 – 35.

Kao,T.T.,Tu,H.C.,Chang,W.N.,Chen,B.H.,Shi,Y.Y.,Chang,T.C.,&Fu,T.F.(2010). Grape seed extract inhibits the growth and pathogenicity of Staphylococcus aureus by interfering with dihydrofolate reductase activity and folate-mediated one-carbon metabolism. *International journal of food microbiology, 141*(1-2), 17-27.

Karthick Raja, P., Aanand, S., Stephen Sampathkumar, J., & Padmavathy, P. (2019). Silkworm pupae meal as alternative source of protein in fish feed. *Journal of Entomology and Zoology Studies, 7*(4), 78-85.

Kaur, Y., Dhawan, A., Naveenkumar, B. T., Tyagi, A., & Shanthanagouda, A. H. (2020). Immuno stimulatory and anti fertility effects of neem (Azadirachta indica) leaf extract on common carp (Cyprinus carpio Linnaeus). *Indian Journal of Animal Research,54*(2), 196-201.

Khalifa, N. S. A., Belal, I. E. H., El- Tarabily, K. A., Tariq, S., & Kassab, A. A. (2018). Evaluation of replacing fish meal with corn protein concentrate in Nile tilapia Oreochromisniloticusfingerlingscommercialdiet.*AquacultureNutrition,24*(1),143- 152.

Kirby, J., & Keasling, J. D. (2009). Biosynthesis of plant isoprenoids: perspectives for microbial engineering. *Annual review of plant biology*, *60*, 335-355.

Kojima, M. (1971). Studies on the effects of isothiocyanates and their analogues on microorganisms. I. Effect of isothiocyanates on the oxygen uptake of yeasts. *J. Ferment. Technol.*, *49*, 740-746.

Kono, M., Matsui, T., & Shimizu, C. (1987). Effect of chitin, chitosan, and cellulose as diet supplements on the growth of cultured fish [red seabream, eel, yellowtail]. *Bulletin of the Japanese Society of Scientific Fisheries (Japan)*.

Kuebutornye,F.K.,Abarike,E.D.,&Lu,Y.(2019).Are view on the application of Bacillus as probiotics in aquaculture. *Fish & shellfish immunology*, *87*, 820-828.

Lamsal, B. P. (2012). Production, health aspects and potential food uses of dairy prebiotic galacto oligosaccharides. *Journal of the Science of Food and Agriculture*, *92* (10), 2020- 2028.

Lange, B., Currie, K. L., Howarth, G.S., & Stone, D.A. (2014). Grapeseed extract and dried macroalgae, Ulva lactuca Linnaeus, improve survival of greenlip abalone, Haliotis laevigata Donovan, at high water temperature. *Aquaculture*, *433*, 348-360.

Langmead, L., Makins, R. J., & Rampton, D. S. (2004). Anti inflammatory effects of aloe vera gelin human colorectal mucosa in vitro. *Alimentary pharmacology & therapeutics*, *19* (5), 521-527.

Lebaka, V. R., Wee, Y. J., Ye, W., & Korivi, M. (2021). Nutritional Composition and Bioactive Compounds in Three Different Parts of Mango Fruit. *International Journal of Environmental Research and Public Health*, *18* (2) , 741. MDPI AG. Retrieved from http://dx.doi.org/10.3390/ijerph18020741

Lee, J. B., Takeshita, A., Hayashi, K., & Hayashi, T. (2011). Structures and antiviral activities of polysaccharides from *Sargassum trichophyllum*. *Carbohydrate Polymers*, *86*(2), 995-999.

Levring, T., Hoppe, H. A., & Schmid, O. Z. (1969). Maine algae – A Survey of research and utilization. *Cram de Grutjter*,*1*, 421.

Leyva-López, N., Lizárraga-Velázquez, C. E., Hernández, C., & Sánchez-Gutiérrez, E. Y. (2020). Exploitation of agro-industrial waste as potential source of bioactive compounds for aquaculture. *Foods*, *9*(7), 843.

Lovkova,M.Y.,Buzuk,G.N.,Sokolova,S.M.,&Kliment'eva,N.I.(2001).Chemicalfeatures of medicinal plants. *Applied Biochemistry and Microbiology*, *37*, 229-237.

Lu,J.,Fu,X.,Liu,T.,Zheng,Y.,Chen,J.,&Luo,F.(2018).Phenoliccomposition,antioxidant, antibacterial and anti-inflammatory activities of leaf and stem extracts from *Cryptotaenia japonica Hassk*. *Industrial Crops and Products*, *122*, 522-532.

Ma, L., Chen, H., Dong, P., & Lu, X. (2013).Anti-inflammatory and anticancer activities of extracts and compounds from the mushroom In onotus obliquus. *Food chemistry*, *139*(1-4), 503-508.

Mahdavi, M., Hajimoradloo, A., & Ghorbani, R. (2013). Effect of Aloe vera extract on growth parameters of common carp (Cyprinus carpio). *World Journal of Medical Sciences*, *9*(1), 55-60.

Makki, K., Deehan, E. C., Walter, J., & Bäckhed, F. (2018). The impact of dietary fiber on gut micro biota in host health and disease. *Cell host & microbe*, *23*(6), 705-715.

Martins, N., Barros, L., & Ferreira, I. C. (2016). In vivo antioxidant activity of phenolic compounds: Facts and gaps. *Trends in Food Science & Technology*, *48*, 1-12.

Mc Hugh, D. J. (2003). A guide to seaweed Industry, FAO Fisheries Technical paper.No.441.

Rome, FAO. Pp 105.

Medina-Gali, R. M., delMarOrtega-Villaizan, M., Mercado, L., Novoa, B., Coll, J., & Perez, L. (2018). Beta-glucan enhances the response to SVCV infection in zebra fish. *Developmental & Comparative Immunology*, *84*, 307-314.

Mehrinakhi, Z., Ahmadifar, E., Sheikhzadeh, N., Moghadam, M. S., & Dawood, M. A. (2020). Extract of grape seed enhances the growth performance, humoral and mucosal immunity, resistance of common carp (*Cyprinus carpio*) against. *Annals of Animal Science*, *21*(1), 217-232.

Meléndez-Martínez,A. J., Mandić,A. I., Bantis, F., Böhm,V., Borge, G. I.A., Brnčić, M., & O'Brien, N. (2022). A comprehensive review on carotenoids in foods and feeds: Status quo applications, patents and research needs. *Critical Reviews in Food Science and Nutrition*, *62*(8), 1999-2049.

Mertens-Talcott, S. U., Jilma-Stohlawetz, P., Rios, J., Hingorani, L., & Derendorf, H. (2006). Absorption, metabolism, and antioxidant effects of pomegranate (*Punica granatum L*.) poly phenols after ingestion of a standardized extract in healthy human volunteers. *Journal of agricultural and food chemistry*, *54*(23), 8956-8961.

Mohammadi Gheisar, M., & Kim, I. H. (2018). Phytobiotics in poultry and swine nutrition–a review. *Italian journal of animal science*, *17*(1), 92-99.

Moo-Huchin, V. M., Moo-Huchin, M. I., Estrada-León, R. J., Cuevas-Glory, L., Estrada-Mota, I. A., Ortiz-Vázquez, E., & Sauri-Duch, E. (2015). Antioxidant compounds, antioxidant activity and phenolic content in peel from three tropical fruits from Yucatan, Mexico. *Food chemistry*, *166*, 17-22.

Morais-Braga, M. F. B., Souza, T. M., Santos, K. K., Guedes, G. M., Andrade, J. C., Vega, C., Rolón, M., Costa, J. G., Saraiva, A. Á. F., & Coutinho, H. D. M. (2013). Phenol composition, cyto toxicandanti- kineto plastidae activities of *Lygodium venustum SW*. (*Lygodiaceae*). *Experimental Parasitology*, *134*(2), 178–182. https://doi.org/10.1016/j.exppara.2013.03.014

Mousavi, S., Zahedinezhad, S., & Loh, J.Y. (2020). A review on insect meals in aquaculture: The immunomodulatory and physiological effects. *International Aquatic Research*, *12*(2), 100-115.

Nagy, M., Semeniuc, C. A., Socaci, S. A., Pop, C. R., Rotar, A. M., Sălăgean, C. D., & tofană, M. (2017). Utilization of brewer's spent grain and mushrooms in fortification of smoked sausages. *Food Science and Technology*, *37*, 315-320.

Nandeesha, M. C., Srikanth, G. K., Varghese, T. G., Keshavanath, P., & Shethy, H. P. C. (1988, November). Influence of silkworm pupae based diets on grown organoleptic quality and biochemical composition of catla-rohu hybrid. In *Aquaculture research in Asia. Management techniques and nutrition. Proceedings of the Asian Seminar on Aquaculture Organized by IFS Malang* (pp. 211-220).

Nasrin, T. A. A., & Matin, M. A. (2017). Valorization of vegetable wastes. *Food Processing By‐ Products and their Utilization*, 53-88.

Ngo, D. H., & Kim, S. K. (2013). Sulfated polysaccharides as bioactive agents from marine algae. *International Journal of Biological Macromolecules*, *62*, 70-75.

NOVASTA® EB15 - AstaReal - Knowde. (n.d.). Knowde. https://www.knowde.com/stores/astareal-inc/products/novasta-eb15

Nurin, F. N., & Maftuch, U. Y. (2018). Larvae of Hermetia illucens promotes the immunocompetence of haematology and muscle histopatology of Common Carp (Cyprinus carpio) challenged with Aeromonas hydrophila. *International Journal of Scientific & Technology Research*, *7*(4), 126-131.

Nwaoguikpe, R. N., Braide, W., & Ezejiofor, T. I. N. (2010). The effect of Aloe vera plant (Aloe barbadensis) extracts on sickle cell blood (hbss). *African Journal of Food Science and Technology*, *1*(3), 058-063.

Obafaye, R. O., & Omoba, O. S. (2018). Orange peel flour:Apotential source of antioxidant and dietary fiber in pearl‐ millet biscuit. *Journal of food biochemistry*, *42*(4), 1-8.

Pacheco-Quito, E. M., Ruiz-Caro, R., & Veiga, M. D. (2020). Carrageenan: drug delivery systems and other biomedical applications. *Marine Drugs*, *18*(11), 583.

Parsaei, P., Bahmani, M., Naghdi, N., Asadi-Samani, M., & Rafieian-Kopaei, M. (2016). A review of therapeutic and pharmacological effects of thymol. *Der Pharm. Lett*,*8*(2), 150-154.

Pereira, A., & Maraschin, M. (2015). Banana (Musa spp) from peel to pulp: ethno pharmacology, source of bioactive compounds and its relevance for human health. *Journal of ethno pharmacology*, *160*, 149-163.

Poorfarid, M., Karimi Jashni, H., & Houshmand, F. (2022). The effects ofAloe Vera sap on progesterone, estrogen and gonadotropin in female rats. *Pars Journal of Medical Sciences*, *10*(4), 7-12.

Prabu, D. L., Sahu, N. P., Pal, A. K., Dasgupta, S., & Narendra, A. (2016). Immunomodulation and interferon gamma gene expression in sutchi cat fish, Pangasianodon hypophthalmus: effect of dietary fucoidan rich seaweed extract (FRSE) on pre and post challenge period. *Aquaculture research*, *47*(1), 199-218.

Pradeepkiran, J.A. (2019).Aquaculture role in global food security with nutritional value: a review. *Translational Animal Science*, *3*(2), 903-910.

Prayitno, S. B.,Ardie, B. R., Novriadi, R., Herawati, V. E., & Windarto, S. (2022). Effect of Bioactive Protein ingredients (Moti VTM) on to Talhemocyte and survival rate of Litopenaeus vannamei. *Indonesian Aquaculture Journal*, *17*(1),23-28.

Premalatha, M., Abbasi, T., Abbasi, T., & Abbasi, S. A. (2011). Energy-efficient food production to reduce global warming and eco degradation: The use of edible insects. *Renewable and sustainable energy reviews*, *15*(9), 4357-4360.

Qin, C., Zhang, Y., Liu, W., Xu, L., Yang, Y., & Zhou, Z. (2014). Effects of chito-oligosaccharides supplementation on growth performance, intestinal cytokine expression, autochthonous gut bacteria and disease resistance in hybrid tilapia *Oreochromis niloticus*♀× *Oreochromis aureus*♂. *Fish & shellfish immunology*,*40*(1), 267-274.

Quinto, B. P. T., Albuquerque, J. V., Bezerra, R. S., Peixoto, S., & Soares, R. (2018). Replacement of fish meal by two types of fish protein hydrolysate in feed for post larval shrimp *Litopenaeus vannamei*. *Aquaculture Nutrition*, *24*(2), 768-776.

Raghav, P. K., & Saini, M. (2018). Antimicrobial properties of Tulsi (*Ocimum sanctum*) in relation to shelf life enhancement of fruits & vegetables. *Int J Green Herbal Chem*,*7*, 20-32.

Rao, P. S., Periyasamy, C., Kumar, K. S., Rao, A. S., & Anantharaman, P. (2018). Seaweeds: distribution, production and uses. *Bioprospecting of algae. Society for Plant Research*, 59-78.

Ren, S. C., Qiao, Q. Q., & Ding, X. L. (2013). Antioxidative activity of five flavon esglycosides from corn silk (Stigma maydis). *Czech Journal of Food Sciences*, *31*(2), 148-155.

Ringø, E., Zhou, Z., Olsen, R. E., & Song, S. K. (2012). Use of chitin and krill in aquaculture– the effect on gut microbiota and the immune system: are view. *Aquaculture Nutrition*, *18*(2), 117-131.

Rupert, R., Rodrigues, K. F., Thien, V. Y., & Yong, W. T. L. (2022). Carrageenan From *Kappaphycus alvarezii (Rhodophyta, Solieriaceae*): Metabolism, Structure, Production, and Application. *Frontiers in Plant Science*, *13*. https://doi.org/10.3389/fpls.2022.859635

Sagar, N. A., Pareek, S., Sharma, S., Yahia, E. M., & Lobo, M. G. (2018). Fruit and vegetable waste: Bioactive compounds, their extraction, and possible utilization. *Comprehensive reviews in food science and food safety*, *17*(3), 512-531.

Salem, M., & Abdel-Ghany, H. M. (2018). Effects of dietary orange peel on growth performance of Nile tilapia (*Oreochromis niloticus*) fingerlings. *Aquaculture studies*, *18*(2), 127-134.

Sarikahya, N. B., Nalbantsoy, A., Top, H., Gokturk, R. S., Sumbul, H., & Kirmizigul, S. (2018). Immuno modulatory, hemolytic and cytotoxic activity potentials of triterpenoid saponins from eight Cephalaria species. *Phytomedicine*, *38*, 135-144.

Shafique, L., Abdel-Latif, H. M., Hassan, F. U., Alagawany, M., Naiel, M. A., Dawood, M. A., & Liu, Q. (2021). The feasibility of using yellow mealworms (Tenebrio molitor): Towards a sustainable aquafeed industry. *Animals*, *11*(3), 811.

Shah, A. S., Gunjal, M. A., & Juvekar, A. R. (2009). Immunomo stimulatory activity of aqueous extract of *Azadirachta indica* flowers on specific and nonspecific immune response. *Journal of Natural remedies*, 35-42.

Sharma, A., Chanu, T. I., & Deo, A. D. (2017). Dietary ashwagandha, *Withania somnifera* (L. dunal) potentiates growth, haemato-biochemical response and disease resistance of Labeo rohita (Hamilton, 1822) against *Aeromonas hydrophila* infection. *Journal of Entomology and Zoology Studies*, *5*(5), 1113-1119.

Shi, F., Qiu, X., Nie, L., Hu, L., Babu, S., Lin, Q., & Qin, Z. (2020). Effects of oligo chitosan on the growth, immune responses and gut microbes of tilapia (*Oreochromis niloticus*). *Fish & Shellfish Immunology*, *106*, 563-573.

Siddik, M. A., Howieson, J., Partridge, G. J., Fotedar, R., & Gholipour-Kanani, H. (2018). Dietary tuna hydrolysate modulates growth performance, immune response, intestinal morphology and resistance to *Streptococcus iniae* in juvenile barramundi, *Lates calcarifer*. *Scientific Reports*, *8*(1). https://doi.org/10.1038/s41598-018-34182-4

Singh, N., Nath, R., Lata,A., Singh, S. P., Kohli, R. P., & Bhargava, K. P. (1982). Withania somnifera (ashwagandha), a rejuvenating herbal drug which enhances survival during stress (an adaptogen). *International journal of Crude drug research*, *20*(1), 29-35.

Singh, S. K., & Patra, A. (2018). Evaluation of phenolic composition, antioxidant, anti-inflammatory and anticancer activities of *Polygonatum verticillatum (L.).Journal of integrative medicine*, *16*(4), 273-282.

Sivaram, V., Babu, M. M., Immanuel, G., Murugadass, S., Citarasu, T., & Marian, M. P. (2004). Growth and immune response of juvenile greasy groupers (*Epinephelus tauvina*) fed with herbal antibacterial active principle supplemented diets against Vibrio harveyi infections. *Aquaculture*, *237*(1-4), 9-20.

Soidrou, S. H., Bousta, D., Lachkar, M., Hassane, S.O.S., Youbi-Hamsas, A. E., Mansouri, L. E., Benjilali, J., El-Hajaji, H., & Farah, A. (2013). Immunomodulatory Activity of Phenolic Fraction from *Piper Borbonense* and *Cassytha Filiformis* Growing in Comoros Islands. In *Springer eBooks*. https://doi.org/10.1007/978-94-007-7389-9_7

Stanić, S. (2007). Anti-genotoxic effect of aloe vera gelR on the mutagenic action of ethyl methanesulfonate. *Archives of Biological Sciences*, *59*(3), 223-226.

Stephenson, T. A., & Stephenson, A. B. (1949). The universal features of zonation between Tide-Marks on Rocky Coasts. *Journal of Ecology*, *37*(2), 289. https://doi.org/10.2307/2256610

Suárez, M., Romero, M. P., & Motilva, M. J. (2010). Development of a phenol-enriched olive oil with phenolic compounds from olive cake. *Journal of agricultural and food chemistry*, *58*(19), 10396-10403.

Suma, A. Y., Nandi, S. K., Kari,Z.A., Goh, K. W., Wei, L. S., Tahiluddin, A., Seguin, P. J., Herault, M., Mamun, A. A., Téllez, G., & Kabir, M. A. (2023). Beneficial Effects of GradedLevelsofFishProteinHydrolysate(FPH)ontheGrowthPerformance,Blood Biochemistry, Liver and Intestinal Health, Economics Efficiency, and Disease Resistance to *Aeromonas hydrophila* of Pabda (*Ompok pabda*) Fingerling. *Fishes*, *8*(3), 147. https://doi.org/10.3390/fishes8030147

Surjushe,A., Vasani, R., & Saple, D. G. (2008). Aloe vera: a short review. *Indian journal of dermatology*, *53*(4), 163.

Svoboda, R.(1992). *Ayurveda: Life, health and longevity*. Penguin Books India.

Talpur, A. D., & Ikhwanuddin, M. (2013). *Azadirachta indica* (neem) leaf dietary effects on the immunity response and disease resistance of Asianseabass, Lates calcarifer challenged with Vibrio harveyi. *Fish & shellfish immunology*, *34*(1), 254-264.

Tejpal, C. S., Kumar, L. R., Elavarasan, K., Renuka,V., & Anas,K. K.(2022). Bioactive based feed formulation for aquaculture applications, *ICAR-CIFT*, 205-207.

Tejpal,C.,Vijayagopal,P.,Elavarasan,K.,Prabu,D.L.,Lekshmi,R.,Anandan,R.,Şanal,E., Asha, K., Chatterjee, N., Mathew, S., & Ravishankar, C. (2021). Evaluation of pepsin derived tilapia fish waste protein hydrolysate as a feed ingredient for silver pompano (*Trachinotus blochii*) fingerlings: Influence on growth, metabolism, immune and diseaseresistance.*AnimalFeedScienceandTechnology*,*272*, 114748. https://doi.org/10.1016/j.anifeedsci.2020.114748

Thirupathi, S. & Subba Rao, P. V. (2004). Manufacture of agar and algin in India. *Seaweed Res Utiln, 26*, Special Issue: 171-173.

Ushakova, N. A., Pravdin, V. G., Kravtsova, L. Z., Ponomarev, S. V., Gridina, T. S., Ponomareva,E.N.,...&Chikindas,M.L.(2021).ComplexBioactiveSupplementsfor Aquaculture—Evolutionary Development of Probiotic Concepts. *Probiotics and Antimicrobial Proteins*, *13*(6), 1696-1708.

Van Doan, H., Tapingkae, W., Moonmanee, T., & Seepai, A. (2016). Effects of low molecular weight sodium alginate on growth performance, immunity, and disease resistance of tilapia, *Oreochromis niloticus*. *Fish & shellfish immunology*, *55*, 186-194.

Veldkamp,T.,Dong,L.,Paul,A.,&Govers,C.C.F.M.(2022).Bioactivepropertiesofinsect productsformonogastricanimals–areview.*JournalofInsectsasFoodandFeed*,*8*(9), 1027-1040.

Veneziani, G., Novelli, E., Esposto, S., Taticchi, A., & Servili, M. (2017). Applications of recovered bioactive compounds in food products. In *Olive mill waste*(pp. 231-253). Academic Press.

Venkataraghavan,S.,Seshadri,C.,Sundaresan,T.P.,Revathi,R., Rajagopalan,V.,&Janaki, K.(1980).Thecomparativeeffectofmilkfortifiedwithaswagandha,aswagandhaand punarnava in children–a double-blind study. *J Res Ayur Sid*, *1*, 370-385.

Vermerris, W., Nicholson, R., Vermerris, W., & Nicholson, R. (2006). Families of phenolic compounds and means of classification. *Phenolic compound biochemistry*, 1-34.

Vig,A.P.,Rampal,G.,Thind,T.S.,&Arora,S.(2009).Bio-protectiveeffectsof glucosinolates–Areview. *LWT-Food Science and Technology*, *42*(10), 1561-1572.

Wang,H.M.D.,Li,X.C.,Lee,D.J.,&Chang,J.S.(2017).Potentialbiomedicalapplications of marine algae. *Bioresource technology*, *244*, 1407-1415.

Windisch, W., & Kroismayr, A. (2007). The effect of phytobioticson performance and gutfunction in monogastrics. Biomin World Nutrition Forum.

Xiao,X.,Jin,P.,Zheng,L.,Cai,M.,Yu,Z.,Yu,J.,&Zhang,J.(2018).Effects of blacksoldier fly(Hermetia illucens) larvae meal protein as a fishmeal replacement on the growth and immune index of yellow catfish (Pelteobagrus fulvidraco). *Aquaculture research*, *49*(4), 1569-1577.

Yang, C., Chowdhury, M. K., Hou, Y., & Gong, J. (2015). Phytogenic compounds as alternativestoin-feedantibiotics:potentialsandchallengesin application. *Pathogens*, *4*(1), 137-156.

Yang, Y., Laval, S., & Yu, B. (2014). Chemical synthesis of saponins. *Advances in carbohydrate chemistry and biochemistry*, *71*, 137-226.

Yousefian, M., Shakour, N., Hosseinzadeh, H., Hayes, A. W., Hadizadeh, F., & Karimi, G. (2019). The natural phenolic compounds as modulators of NADPH oxidases in hypertension. *Phytomedicine*, *55*, 200-213.

Zhai, S. W., Lu, J. J., & Chen, X. H. (2014). Effects of dietary grape seed proanthocyanidins ongrowthperformance,someserumbiochemicalparametersandbodycompositionof tilapia (Oreochromis niloticus) fingerlings. *Italian Journal of Animal Science*,*13*(3), 3357.

Zhang,X.,Guo,Y.,Wang,C.,Li,G.,Xu,J.,Chung,H.Y.,Ye,W.,Li,Y.,&Wang,G.(2014). Phenolic compounds from Origanum vulgare and their antioxidant and antiviral activities. *Food Chemistry*, *152*, 300–306. https://doi.org/10.1016/j.foodchem.2013.11.153

Ziauddin,M.,Phansalkar,N.,Patki,P.,Diwanay,S.,&Patwardhan,B.(1996).Studiesonthe immunomodulatory effects of Ashwagandha.*Journal of ethnopharmacology*,*50*(2), 69-76.

Žilić, S., Janković, M., Basić, Z., Vančetović, J., & Maksimović, V. (2016). Antioxidant activity,phenolicprofile,chlorophyllandmineralmattercontentofcornsilk(Zeamays L):

Comparison with medicinal herbs. *Journal of Cereal Science*, *69*, 363-370.

Zsolnai,T.(1966).[Theantimicrobialactivityofthiocyanatesandisothiocyantes 1].*PubMed*, *16*(7), 870–876. https://pubmed.ncbi.nlm.nih.gov/4967663