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Review Article

Recent Advances of Phytobiotic Utilization in Carp Farming: A Review

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Carp farming is a popular aquaculture activity that provides affordable protein sources and job opportunities to many people worldwide. As carp farming intensifies, farmers face major issues such as rising feed costs and excessive antibiotic usage. Thus, there is an urgent need to explore alternative resources to ensure the sustainability of the carp farming industry. One of the most promising resources is phytobiotics that possess various properties beneficial for carp production. Furthermore, most phytobiotics are derived from agricultural waste that is abundant and cheap, but some phytobiotics are produced commercially and available in the market. The main topics of this review are highlighted sources, characteristics of phytobiotics, and the usefulness of phytobiotics in improving growth performance, feed utilization efficiency, antioxidant activity, and health of carps against diseases. Furthermore, in this review, recent methods of administration of phytobiotics such as through feeding, bathing, and intraperitoneal injection in carp farming are also discussed and summarised.

1. Introduction

Carp, alongside tilapia and shrimp, are the main aquaculture species that made up 50% of the total world aquaculture production in 2018 [1]. The first carp farming was recorded 2500 years ago, and carp continues to be cultured in 123 countries today, with 28.9 million tons of production valued at USD 61.6 billion in 2018 [2]. The common carp production alone exceeded 4000 tons or 7.7% of the world's aquaculture production in 2018 [2]. China has remained the

Table 1: Phytobiotics that improved carp growth performance.

Phytobiotics	Dose	Duration	References
Rapeseed cake	330 g/kg diet	50 days	Mazurkiewicz et al. [10]
Basil (*Ocimum basilicum*) ethanolic extract	400 mg/kg diet	2 months	Amirkhani and Firouzbakhsh [15]
Defatted rubber seed meal replacement of fish meal	50%	8 weeks	Suprayudi et al. [11]
Fenugreek seed meal	1%/kg diet	8 weeks	Roohi et al. [16]
Rapeseed+Chlorella meal fish meal replacement	25–100%	6 weeks	Shi et al. [12]
Date palm (*Phoenix dactylifera*) seed extract	0.5%/kg diet	60 days	Mohammadi et al. [17]
Spirulina platensis as a fish meal replacement, supplemented lysine	50-100%	60 days	Cao et al. [22]
Chlorella	1-4%/kg diet	8 weeks	Luo et al. [18]
Juniper berry oil	5 ml/kg diet	8 weeks	Kesbiç [19]
White button mushroom powder	0.5–2%/kg diet	8 weeks	Hoseinifar et al. [20]
Curcumin	120-600 mg/kg diet	60 days	Li et al. [21]
Tea polyphenols	50 mg/kg diet	8 weeks	Zhong et al. [23]
Fern (*Adiantum capillus-veneris*) leaf powder	1-2%/kg diet	56 days	Hoseinifar et al. [24]
Wheat meal	40%	8 weeks	Lin et al. [14]
Chaste tree fruit extract	1.5%/kg diet	56 days	Rashmeei et al. [25]
Tea polyphenol	500 mg/kg diet	8 weeks	Rizwan et al. [26]
Wheatgrass (*Triticum aestivum* L.) juice	1-4%/kg diet	60 days	Barbacariu et al. [27]
Orange peel-derived pectin	1%/kg diet	8 weeks	Hosseini et al. [28]
Ginger (*Zingiber officinale*) extract	0.2%/kg diet	60 days	Mohammadi et al. [29]
Medicinal plant extract mixture: common mallow (*Malva sylvestris*), oregano (*Origanum vulgare*), and Persian shallot (*Allium hirtifolium*)	2-3%/kg diet	60 days	Ghafarifarsani et al. [30]
Defatted *Schizochytrium* sp.	41.08–60 g/kg diet	8 weeks	Xiao et al. [31]
Nigella sativa seed	1-2.5%/kg diet	28 days	Latif et al. [32]
Afsanteen (*Artemisia absinthium*) aqueous extract	0.5–1%/kg diet	60 days	Yousefi et al. [33]
Grape pomace flour (GPF)	300 mg/kg diet	8 weeks	Harikrishnan et al. [34]
Apple peel-derived pectin	0.5–2%/kg diet	8 weeks	Hoseinifar et al. [35]
Marjoram (*Origanum majorana*) extract	200 mg/kg diet	8 weeks	Yousefi et al. [36]
Herb extracts mixture: coriander (*Coriandrum sativum*), common mallow (*Malva sylvestris*), and oak acorn (*Quercus brantii*)	1%/kg diet	60 days	Raissy et al. [37]
Savory (*Satureja hortensis*) essential oil	200 mg/kg diet	60 days	Ghafarifarsani et al. [38]
Taraxacum mongolicum polysaccharide	1 g/kg diet	56 days	Yu et al. [39]

leading carp producer in the world since 1997, with 5.7 million tons of carp production in 2018, followed by India and Bangladesh [2]. The major carp species farmed worldwide are grass carp, silver carp, common carp, bighead carp, and catla. Furthermore, carp production is expected to increase in the coming years due to the rising global market demand. However, there are several issues in carp farming that have limited the expansion of carp production.

Carp farming is susceptible to huge losses due to disease outbreaks. When carp production is affected, it will lead to loss of income and unemployment among farmers [1, 3]. Traditionally, fish farmers depend on antibiotics to mitigate disease outbreaks, but this practice has led to overreliance and antibiotic resistance of pathogenic bacteria in aquaculture sites [4]. Therefore, it is essential to identify an alternative antimicrobial agent for aquaculture species health management. In addition, many European countries have banned aquaculture products containing antibiotic residues [4]. Phytobiotic is a potential solution in improving aquaculture species' health and function while minimizing antibiotic dependence.

Carp farming has also become increasingly expensive due to the rising cost of conventional raw materials for feed formulation [3]. Prices of feed ingredients such as soybean meal and fish meal continue to rise since these conventional raw materials are also utilized in the feed formulation of other livestock. Thus, an alternative to the current raw materials for feed formulation is urgently needed to maintain the cost of carp production and ensure the stability and sustainability of the carp farming industry. Currently, farmers are looking at phytobiotics as an alternative resource to the conventional raw materials for carp farming for safe and sustainable carp production.

Phytobiotics refer to plant-based extracts, derivatives, bioactive compounds, whole plant, or part of a plant utilized

Table 2: Phytobiotics that improved carp feed utilization efficiency.

Phytobiotics	Dose	Duration	References
Basil (*Ocimum basilicum*) ethanolic extract	400 mg/kg diet	2 months	Amirkhani and Firouzbakhsh [15]
Spirulina platensis, fish meal replacement, supplemented lysine	50-100%	60 days	Cao et al. [22]
Bamboo charcoal	0.5-4%/kg diet	63 days	Mabe et al. [41]
Oregano essential oil	500 mg–4500 mg/kg diet	8 weeks	Zhang et al. [40]
Curcumin	120-600 mg/kg diet	60 days	Li et al. [21]
Mixture of three medicinal plant extracts: common mallow (*Malva sylvestris*), oregano (*Origanum vulgare*), and Persian shallot (*Allium hirtifolium*)	2-3%/kg diet	60 days	Ghafarifarsani et al. [30]
Afsanteen (*Artemisia absinthium*) aqueous extract	0.5–1%/kg diet	60 days	Yousefi et al. [33]
Apple peel-derived pectin	0.5–2%/kg diet	8 weeks	Hoseinifar et al. [35]
Grape pomace flour (GPF)	300 mg/kg diet	8 weeks	Harikrishnan et al. [34]
Herb extract mixture: coriander (*Coriandrum sativum*), common mallow (*Malva sylvestris*), and oak acorn (*Quercus brantii*)	1%/kg diet	60 days	Raissy et al. [37]
Savory (*Satureja hortensis*) essential oil	200 mg/kg diet	60 days	Ghafarifarsani et al. [38]

as feed additives or raw materials for feed formulation to improve livestock production [5–7]. Feeding, intraperitoneal injection, and bath immersion are available options to deliver these polysaccharides to the fish. Various studies have revealed the potential of phytobiotics in improving carp growth performance, feed utilization efficiency, antioxidant activities, innate immune response, and carps' health against diseases, which will be further discussed in this review.

2. Phytobiotic Sources and Characteristics

What are phytobiotics? Phytobiotics are referred to as a group of plant-based products or compounds that can benefit animal farming including humans [6]. Phytobiotics can be found naturally and abundant in vegetables, fruits, herbs, legumes, and essential oils [8]. They can be used as whole plants or through extracting their bioactive compounds such as phenolic compounds, carotenoids, alkaloids, and many more [8]. The presence of bioactive compounds in phytobiotics will determine the characteristics of the phytobiotics. For example, the presence of phenolic compounds in phytobiotics can contribute to the antioxidant property of phytobiotics [9]. Besides, phytobiotics were reported to possess other huge characteristics such as anti-inflammatory and antimicrobial. Therefore, phytobiotics were widely used in animal production as growth promoters and prophylactic agents to increase animal production.

3. The Role of Phytobiotics in Improving Carp Growth Performance

Phytobiotic is a growth promoter and a protein replacement for conventional raw materials like fish and soybean meals. This plant-based material positively impacts the gut microflora and encourages digestive enzyme secretion [7]. Examples of phytobiotics include rapeseed cake [10], defatted rubber seed meal [11], and a combination of rapeseed and Chlorella meal [12]. These alternative and protein-rich feedstuffs can help reduce operational costs in carp farming by using as fish meal protein replacement in fish feed formulation.

However, not all plant-based products are beneficial in fish farming. Fish feed high in starch content has adverse effects on fish growth performance. For example, Tan et al. [13] reported that fish feed with high starch concentration (32-40%) negatively affected the growth performance of gibel carp (*Carassius auratus*). Thus, fish farmers must select the appropriate plant-based product as phytobiotics for their aquaculture species.

Many studies reported on the role of phytobiotic in enhancing carp growth performance as shown in Table 1. For example, Lin et al. [14] claimed that fish feed consisting of 40% wheat meal could promote fish growth since it is rich in the amino acid leucine. Meanwhile, Amirkhani and Firouzbakhsh [15] revealed that a 400 mg/kg diet of the basil (*Ocimum basilicum*) ethanolic extract could improve the growth performance of the common carp (*Cyprinus carpio*). In addition, other phytobiotics that positively influenced aquaculture species growth performances are fenugreek seed meal [16], date palm (*Phoenix dactylifera*) seed extract [17], Chlorella [18], juniper berry oil [19], white button mushroom powder [20], curcumin [21], and wheat meal [14]. Moreover, certain phytobiotics such as fenugreek seed meal exhibited additional benefits by reducing stress and improving growth performance [16]. On top of that, phytobiotics such as fenugreek seed meal, Chlorella, juniper berry oil, and curcumin are abundant, making them accessible to most farmers.

4. The Role of Phytobiotics in Promoting Carp Feed Utilization Efficiency

Feed utilization efficiency is crucial in determining the success of carp farming. Phytobiotic application improves nutrient availability and digestibility, contributing to enhanced feed conversion and protein synthesis [7]. Various phytobiotics like oregano essential oil [40], curcumin [21],

Table 3: Phytobiotics in enhancing antioxidant activities in carps.

Phytobiotics	Dose	Duration	References
Date palm extract	200 ml/kg diet	8 weeks	Hoseinifar et al. [45]
Bamboo charcoal	0.5-4%/kg diet	63 days	Mabe et al. [41]
Chlorella	1-4%/kg diet	8 weeks	Luo et al. [18]
Oregano essential oil	500 mg–4500 mg/kg diet	8 weeks	Zhang et al. [40]
Fern (*Adiantum capillus-veneris*) leaf powder	1-2%/kg diet	56 days	Hoseinifar et al. [24]
Artemisia (*Artemisia annua*) leaf extract	0.5–2 g/kg diet	30 days	Mirghaed et al. [46]
Tea polyphenols	50 mg/kg diet	8 weeks	Zhong et al. [23]
Oak (*Quercus castaneifolia*) leaf extract	1-2 g/kg diet	60 days	Paray et al. [47]
Dried lemon (*Citrus limon*) peel	2.5-5 g/kg diet	60 days	Harikrishnan et al. [48]
Garlic	1-1.5%/kg diet	35 days	Yousefi et al. [43]
Orange peel-derived pectin	1%/kg diet	8 weeks	Hosseini et al. [28]
Ulvan	25-50 mg/kg diet	8 weeks	Harikrishnan et al. [44]
Russian olive (*Elaeagnus angustifolia*)	1%/kg diet	8 weeks	Hoseini et al. [49]
Apple peel-derived pectin	0.5–2%/kg diet	8 weeks	Hoseinifar et al. [35]
Black seed (*Nigella sativa*)	0.25–1%/kg diet	60 days	Yousefi et al. [50]
Medicinal plant extract mixture: common mallow (Malva sylvestris), oregano (*Origanum vulgare*), and Persian shallot (*Allium hirtifolium*)	2-3%/kg diet	60 days	Ghafarifarsani et al. [30]
Nigella sativa seed	1-2.5%/kg diet	28 days	Latif et al. [32]
Afsanteen (*Artemisia absinthium*) aqueous extract	0.5-1%/kg diet	60 days	Yousefi et al. [33]
Marjoram (*Origanum majorana*) extract	200 mg/kg diet	8 weeks	Yousefi et al. [36]
Grape pomace flour (GPF)	300 mg/kg diet	8 weeks	Harikrishnan et al. [34]
Savory (*Satureja hortensis*) essential oil	200 mg/kg diet	60 days	Ghafarifarsani et al. [38]
Herb extract mixture: coriander (*Coriandrum sativum*), common mallow (*Malva sylvestris*), and oak acorn (*Quercus brantii*)	1%/kg diet	60 days	Raissy et al. [37]
Taraxacum mongolicum polysaccharide	1 g/kg diet	56 days	Yu et al. [39]

grape pomace flour (GPF) [34], and savory (*Satureja hortensis*) essential oil [38] are easily applicable in carp farming as shown in Table 2. Nevertheless, these phytobiotics are only useful when the aquaculture species nutritional requirements are fulfilled. High feed utilization efficiency will result in a low feed conversion rate (FCR), thus boosting the income of carp farmers.

5. The Role of Phytobiotics in Enhancing Carp Antioxidant Activities

Numerous studies have revealed the potential of phytobiotics in enhancing antioxidant activities in carps as shown in Table 3. Antioxidants are essential for protection against free radicals and oxidative stress [42]. Moreover, some phytobiotics are inexpensive in the market, making them accessible to most carp farmers. Examples of phytobiotics that promote antioxidant activities in carps are Chlorella [18], garlic [43], ulvan [44], and grape pomace flour (GPF) [34]. Nonetheless, inadequate resources and the high processing cost of the current technology are limitations to the phytobiotic application in carp farming [3, 5].

5.1. The Role of Phytobiotics in Activating an Innate Immune Response in Carps. Like higher vertebrates, the fish immune system consists of two components: (1) innate immunity and (2) adaptive immunity. The first line of defence in fish is the innate immune system during the pathogenic invasion. In aquaculture, the most reliable disease management is through immunostimulant administration [51]. Some phytobiotics act as immunostimulants and promote antioxidant activities in carps but do not contribute to their growth performance. For example, Paray et al. [47] revealed that oak (*Quercus castaneifolia*) leaf extract-medicated feed for 60 days in common carp (*Cyprinus carpio*) enhanced antioxidant activities and promoted their immune system but did not influence carps' growth rate.

Generally, phytobiotics with high antioxidant properties can stimulate the fish immune system [52]. Some phytobiotics are low cost and easy to access such as garlic [43], grape pomace flour (GPF) [34], ulvan [44], and turmeric powder [53], which can be used to boost carps' immune response and increase fish production as shown in Table 4. However, certain plant-based products must be processed before they can be used as an aquaculture feed additive, such as *Psidium guajava* leaf [54] and dried lemon (*Citrus limon*) peel [48]. These agricultural wastes are subjected to drying and converted into powder form before being used as phytobiotics to enhance the immune system of carps.

Table 4: Phytobiotics that activate innate immune response in carps.

Phytobiotics	Dose	Duration	References
Zataria multiflora essential oil	30-120 ppm	8 days	Soltani et al. [55]
Zataria multiflora and *Eucalyptus globulus* essential oils	30–120 ppm	8 days	Sheikhzadeh et al. [56]
Achyranthes aspera seed (powder)	1%/kg diet	30 days	Chakrabarti et al. [57]
Date palm fruit extract	200 ml/kg diet	8 weeks	Hoseinifar et al. [45]
Agaricus bisporus (powder)	1-2%/kg diet	8 weeks	Zou et al. [58]
Purple coneflower	4 g/kg diet	8 weeks	Tang et al. [59]
Medler (*Mespilus germanica*) leaf extract	0.5-1%/kg diet	49 days	Hoseinifar et al. [60]
Date palm extract	200 ml/kg diet	8 weeks	Hoseinifar et al. [61]
Jujube (*Ziziphus jujuba*) fruit extract	0.25-1%/kg diet	8 weeks	Hoseinifar et al. [62]
Jujube (*Ziziphus jujuba* Mill.)	0.25-1%/kg diet	8 weeks	Hoseinifar et al. [63]
Psidium guajava leaf	0.25-1%/kg diet	8 weeks	Hoseinifar et al. [54]
Garlic	1-1.5%/kg diet	35 days	Yousefi et al. [43]
Oak (*Quercus castaneifolia*) leaf extract	1-2 g/kg diet	60 days	Paray et al. [47]
Ginger (*Zingiber officinale*) extract	0.2%/kg diet	60 days	Mohammadi et al. [29]
Orange peel-derived pectin	1%/kg diet	8 weeks	Hosseini et al. [28]
Fern (*Adiantum capillus-veneris*) leaf powder	1-2%/kg diet	56 days	Hoseinifar et al. [24]
Dried lemon (*Citrus limon*) peel	2.5-5 g/kg diet	60 days	Harikrishnan et al. [48]
Apple peel-derived pectin	0.5–2%/kg diet	8 weeks	Hoseinifar et al. [35]
Black seed (*Nigella sativa*)	0.25–1%/kg diet	60 days	Yousefi et al. [50]
Marjoram (*Origanum majorana*) extract	200 mg/kg diet	8 weeks	Yousefi et al. [36]
Grape pomace flour (GPF)	300 mg/kg diet	8 weeks	Harikrishnan et al. [34]
Russian olive (*Elaeagnus angustifolia*)	1%/kg diet	8 weeks	Hoseini et al. [49]
Ulvan	25-50 mg/kg diet	8 weeks	Harikrishnan et al. [44]
Afsanteen (*Artemisia absinthium*) aqueous extract	0.5–1%/kg diet	60 days	Yousefi et al. [33]
Medicinal plant extract mixture: common mallow (*Malva sylvestris*), oregano (*Origanum vulgare*), and Persian shallot (*Allium hirtifolium*)	2-3%/kg diet	60 days	Ghafarifarsani et al. [30]
Turmeric powder	1%/kg diet	2 weeks	Hoseini et al. [53]
Herb extract mixture: coriander (*Coriandrum sativum*), common mallow (*Malva sylvestris*), and oak acorn (*Quercus brantii*)	3%/kg diet	60 days	Raissy et al. [37]
Savory (*Satureja hortensis*) essential oil	200 mg/kg diet	60 days	Ghafarifarsani et al. [38]
Taraxacum mongolicum polysaccharide	1 g/kg diet	56 days	Yu et al. [39]

5.2. Antioxidant Activities of Phytobiotics. Plant-based phytobiotics are rich in antioxidants with different total antioxidant capacities, which will determine the potential of the plant as a source of antioxidants. Bioactive compounds such as phenols, phenolic acids, coumarins, flavonoids, stilbenes, tannin, lignans, and lignin determine the plants' total antioxidant capacity [64]. Many scientific approaches have been developed to quantify the total antioxidant capacity of plant extracts [65]. The main attraction of phytobiotics is their abundance and low cost, making them a source of antioxidant feed additive for aquaculture to enhance aquaculture species health and production [66]. Nevertheless, fish farmers prefer nontoxic materials for their aquaculture species, high antioxidant activity at low dosage, and inexpensive fish feed formulation.

6. The Role of Phytobiotics in Stimulating Carps' Health against Diseases

Motile Aeromonas Septicemia (MAS) caused by *Aeromonas hydrophila* and spring viraemia of carp virus (SVCV) are two diseases that pose a major threat and lead to significant economic losses in carp farming. Various studies have attempted the search for potential treatments or phytobiotics against these diseases. Traditionally, fish farmers use antibiotics in carp farming health management, but recent discoveries suggested phytobiotics as potential antimicrobial agents to stimulate carp resistance against diseases like MAS and SVCV. Furthermore, some of the proposed phytobiotics are commercially available in the market, thus highly accessible to fish farmers to be applied instantly in their farms to prevent disease outbreaks. Examples of potential phytobiotics against diseases are garlic, *Allium sativum* [67], tapioca [68], spirulina, *Arthrospira platensis* [69], and curcumin [70] as shown in Table 5. Other phytobiotics were also found effective in disease control but not readily available in the market. Based on a literature survey, only one study was using dipping to expose phytobiotics to carp species [71]. Although the study showed promising result, it is not practical to use in a large scale such as in an earthen pond. Hence, exposure phytobiotics to carp fish via feeding is the most cost-effective way.

Table 5: Phytobiotics that promote carps' health against diseases.

Phytobiotics	Pathogen	Host	Dose/period	References
Garlic (*Allium sativum*)	*Aeromonas hydrophila*	Rohu (*Labeo rohita*)	1–10 g/kg of fish +10 days	Sahu et al. [67]
Mixed herbal extract (neem leaf, tulsi, and turmeric)	*Aeromonas hydrophila*	Goldfish (*Carassius auratus*)	Dipping in 1% solution of 10 ppt	Harikrishnan et al. [71]
Mixed herbal extracts	*Aeromonas hydrophila*	Goldfish (*Carassius auratus*)	400–800 mg/kg diet+4 weeks	Harikrishnan, et al. [72]
Basil (*Ocimum basilicum*) ethanolic extract	*Aeromonas hydrophila*	Common carp (*Cyprinus carpio* L.)	400 mg/kg diet+2 months	Amirkhani and Firouzbakhsh [15]
Psidium guajava L. leaves	*Aeromonas hydrophila*	*Labeo rohita*	0.5% of diet+60 days	Giri et al. [73]
Tapioca	*Aeromonas hydrophila*	*Labeo rohita* fingerling	C/N ratio 15+60 days	Irshad et al. [68]
Ficus carica, *Radix isatidis*, *Schisandra chinensis* polysaccharides	*Aeromonas hydrophila*	Crucian carp	<0.8/kg diet+4 weeks	Wang et al. [74]
Spirulina (*Arthrospira platensis*)	*Aeromonas hydrophila*	Gibel carp (*Carassius auratus gibelio* var. CAS III)	13.53 g/100 g diet +46 days	Cao et al. [69]
Ginkgo biloba leaf extract	*Aeromonas hydrophila*	Common carp (*Cyprinus carpio* L.)	10 g/kg diet+8 weeks	Bao et al. [75]
Oregano essential oil	*Aeromonas hydrophila*	Koi carp (*Cyprinus carpio*)	500 mg to 4500 mg/kg diet	Zhang et al. [40]
Ulvan	*Flavobacterium columnare*	*Labeo rohita*	25-50 mg/kg diet	Harikrishnan et al. [44]
Grape pomace flour (GPF)	*Flavobacterium columnare*	*Labeo rohita*	300 mg/kg diet	Harikrishnan et al. [34]
Origanum essential oil	*Aeromonas hydrophila*	Common carp (*Cyprinus carpio* L.)	15 g/kg diet+8 weeks	Abdel-Latif et al. [76]
Chasteberry (*Vitex agnus-castus*) extract	*Aeromonas hydrophila*	Goldfish (*Carassius auratus*)	15 g/kg of diet+8 weeks	Rashmeei et al. [77]
Fermented moringa (*Moringa oleifera* Lam)	*Aeromonas hydrophila*	Goldfish (*Carassius auratus*)	40% replacement of fish meal+50 days	Zhang et al. [78]
Curcumin	*Aeromonas hydrophila*	Grass carp (*Ctenopharyngodon idella*)	438.20 mg/kg diet +60 days	Ming et al. [70]
Marjoram (*Origanum majorana*) extract	*Aeromonas hydrophila*	Common carp (*Cyprinus carpio* L.)	200 mg/kg diet	Yousefi et al. [36]
Ficus carica polysaccharides	*Aeromonas hydrophila*	Crucian carp	0.4%/kg diet+4 weeks	Wang et al. [74]
Flos populi extract	*Aeromonas hydrophila*	Goldfish (*Carassius auratus*)	1-2 g/kg diet+45 days	Zhang et al. [79]
Astragalus polysaccharides	Spring viraemia of carp virus	Crucian carp	2 g/kg diet+56 days	Liu et al. [80]
Herb extract mixture; coriander (*Coriandrum sativum*), common mallow (*Malva sylvestris*), and oak acorn (*Quercus brantii*)	*Aeromonas hydrophila*	Common carp (*Cyprinus carpio* L.)	3%/kg diet+60 days	Raissy et al. [37]

Table 6: Phytobiotic combination with other antimicrobial/therapeutic agents to improve disease resistance and growth rates of carps.

Phytobiotics	Supplements	Dose	Duration	Application	References
Fermented *Astragalus membranaceus*	*Lactobacillus plantarum*	0.1-0.4%/kg diet	8 weeks	Growth/health	Shi et al. [81]

6.1. Phytobiotic Combination with Other Supplements for Disease Resistance and Growth Rate Improvements of Carps. Currently, studies on the synergistic effects of phytobiotics with other supplements are still lacking. To date, only one synergistic study has been conducted on fermented *Astragalus membranaceus* and *Lactobacillus plantarum* in promoting common carp (*Cyprinus carpio*) growth performance [81] as shown in Table 6. Therefore, more synergistic studies involving phytobiotics with other supplements should be carried out to enhance carp farming production in the future.

7. Conclusion and Recommendation

The study of application of phytobiotics in carp farming is well documented in the literature. Phytobiotics are abundant and inexpensive where some can be found from agricultural wastes and some are commercially available in the market. Phytobiotics can help to improve growth performance of carp farming as protein source replacement and served as prebiotic to increase digestibility of the fish. This will reduce reliance on conventional protein sources such as fishmeal and soymeal in carp farming. Recent studies revealed the huge potential of phytobiotics in modulating the immune system and disease resistance of carp against various diseases. The novel findings showed that phytobiotics are ready to replace antibiotic as a prophylactic agent in carp farming health management. Application of these less ecological footprint prophylactic agents in carp farming can gain confidence of consumer to the aquaculture products. However, dosage and duration effects were the problems in administration of phytobiotics in carp farming. Different dosages and durations of phytobiotic application in carp farming will generate variable results. Besides, experimental conditions and the sources of phytobiotics may also play roles in determining the effectiveness of phytobiotics in carp farming. The administration of phytobiotics in carp farming can be applied orally and through intraperitoneal injection or bathing. Although the intraperitoneal method and bathing were found more effective, the methods need high labour work. Hence, most of studies recommended using phytobiotics as a feed additive in carp farming. Furthermore, oral administration of phytobiotics is a nonstressful method and practical and suitable to all sizes of fish. In conclusion, phytobiotics are rich in nutrients and bioactive compounds that help promote fish growth, digestibility, antioxidant activities, immunity, and resistance to diseases. Thus, this plant-based feed is a promising raw material for the future of aquaculture. Furthermore, most phytobiotics are derived from agricultural wastes; thus, utilizing these materials improves agricultural management and sustainability. Further study needs to be carried out on the potential phytobiotics by screening their toxicity as a prerequisite for their application in carp farming in order to produce a database on appropriate dosage as a usage guideline to the carp fish farmer.

Data Availability

This paper only reviews published literatures, and no data was collected.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could influence the work reported in this paper.

Authors' Contributions

Zulhisyam Abdul Kari was responsible for the conceptualisation and writing of the original draft. Wendy Wee, Noor Khalidah Abdul Hamid, Hazreen Nita Mohd Khalid, Suniza Anis Mohamad Sukri, Khairiyah Mat, Nor Dini Rusli, Hasnita Che Harun, Ali Hanafiah Hakim, and Martina Irwan Khoo were responsible for the review and editing of the manuscript. Mahmoud Abdelhamid Omran Dawood was responsible for the supervision and conceptualization. Khang Wen Goh was responsible for the funding, writing of the original draft, and review and editing of the manuscript. Lee Seong Wei was responsible for the project administration, writing of the original draft, and review and editing of the manuscript.

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