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مجلة النماء للعلوم و التكنولوجيا

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مجلة علمية محكمة سنوية تصدر عن
كلية الزراعة جامعة الزيتونة

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مجلة علمية محكمة تصدر عن كلية الزراعة جامعة الزيتونة

تنويه

1. المجلة ترحب بما يصل إليها من أبحاث وعلى استعداد لنشرها بعد التحكيم.
2. المجلة تحترم آراء المحكمين وتعمل بمقتضاها.
3. كافة الآراء والأفكار المنشورة تعبر عن آراء أصحابها فقط.
4. يتحمل الباحث مسؤولية الأمانة العلمية وهو المسؤول عما ينشر عنه.
5. البحوث المقدمة للنشر لا ترد لأصحابها سواءً نشرت أو لم تنشر.

مجلة النماء للعلوم والتكنولوجيا

السنة الرابعة العدد الرابع المجلد (1) مارس 2023

مجلة علمية محكمة - تصدر دورية سنوية - عن كلية الزراعة جامعة الزيتونة

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مجلة النماء للعلوم والتكنولوجيا: مجلة علمية دورية محكمة تصدر عن كلية الزراعة جامعة الزيتونة تعنى بالبحوث والدراسات المبتكرة في مختلف العلوم التطبيقية وتقبل نشر الأبحاث العلمية الأصيلة والنتائج العلمية المبتكرة.

الرسالة

الاسهام في نشر العلوم والمعارف الحديثة باستخدام أحدث معايير وتقنيات النشر والطباعة، ودعم الإبداع الفكري والتوظيف الأمثل للتقنية والشراكة المحلية والعالمية الفاعلة.

الرؤيـة

الارتقاء بإصدارات المجلة لتصبح مصادر معرفة ذات قيمة علمية تفيد المجتمع، والريادة العالمية والتميز في نشر البحوث العلمية.

الأهداف

1- تحقيق تقدم في التصنيفات العالمية عن طريق تقوية الجامعة بأكملها، والتميز بحثياً وتعليمياً في كافة المجالات.

2- استقطاب وتطوير أعضاء هيئة تحكيم واستشاريين متميزون.

3- تحقيق الجودة المطلوبة للبحث العلمي.

4- تمكين الباحثين والمحكمين من اكتساب المهارات الفكرية والمهنية أثناء حياتهم البحثية والعلمية.

5- بناء جسور التواصل داخل الجامعة وخارجها مع الجامعات الأخرى المحلية والإقليمية والعالمية.

قواعد النشر

تصدر المجلة وفق مبادئ الدين الإسلامي الحنيف، ووفق قوانين الإصدار للدولة الليبية، وكذلك وفق رؤية ورسالة وأهداف جامعة الزيتونة.

قواعد و شروط النشر بمجلة النماء للعلوم و التكنولوجيا كلية الزراعة جامعة الزيتونة

1- أن يكون البحث لم يسبق نشره في أي جهة أخرى وأن يتعهد الباحث كتابة بذلك.

2- أن يكون البحث مكتوباً بلغة سليمة، ومراعياً لقواعد الضبط ودقة الرسوم والأشكال إن وجدت، ومطبوعاً بخط (Simplified Arabic) للغة العربية، وبخط (Times News Roman) للغة الأجنبية، وبحجم (12)، وبمسافة مفردة بين الأسطر، وأن تكون أبعاد الهوامش للصفحة من أعلى وأسفل (4 سم) ومن الجانبين (3 سم)، وألا يزيد البحث عن (25) صفحة.

3- أن تكون الجداول والأشكال مدرجة في أماكنها الصحيحة، وأن تشمل العناوين والبيانات الايضاحية الضرورية، ويراعى ألا تتجاوز أبعاد الأشكال و الجداول حجم حيز الكتابة في صفحة Microsoft Word.

4- أن يكون البحث ملتزماً بدقة التوثيق، وحسن استخدام المراجع، وأن يراعى اتباع نظام (APA) في توثيق المراجع داخل النص وفي كتابة المراجع نهاية البحث.

5- تحتفظ المجلة بحقها في اخراج البحث وإبراز عناوينه بما يتناسب واسلوبها في النشر.

6- تنشر المجلة البحوث المكتوبة باللغة الأجنبية شريطة أن ترفق بملخص باللغة العربية لا يتجاوز 250 كلمة.

7- ترسل نسخة من البحث مطبوعة على ورق حجم (A4) إلى مقر المجلة، أو نسخة إلكترونية إلى البريد الالكتروني للمجلة (annamaa@azu.edu.ly)، على أن يكتب على صفحة الغلاف: اسم الباحث ثلاثي، مكان عمله، تخصصه، رقم الهاتف والبريد الإلكتروني.

8- يتم تبليغ الباحث بقرار قبول البحث أو رفضه خلال مدة أقصاها ستون يوماً من تاريخ استلام البحث، وفي حالة الرفض فالمجلة غير ملزمة بذكر أسباب عدم القبول.

9- في حالة ورود ملاحظات وتعديلات على البحث من المحكم يتم ارسالها للباحث لإجراء التعديلات المطلوبة وعليه الالتزام بها، على أن يعاد إرسالها للمجلة خلال فترة أقصاها خمسة عشر يوماً.

10- أن يلتزم الباحث بعدم إرسال بحثه لأية جهة أخرى للنشر حتى يتم اخطاره برد المجلة.

11- دفع الرسوم المخصصة للتحكيم العلمي وللمراجعة اللغوية والنشر، إن وجدت.

كلمة افتتاحية

الحمد لله حمداً كثيراً طيباً مباركاً فيه، والصلاة والسلام على محمد وعلى آله وصحبه أجمعين.

يسعد أسرة مجلة النماء للعلوم والتكنولوجيا أن تقدم للباحثين أصدق التحيات وأعطرها بعد إصدارها بشكل منتظم وردود الفعل التي تلقيناها والتي كانت لنا بمثابة دافع لمواصلة السير قدماً، لتطوير بيت الخبرة، لكي يكون استمراراً للجهود المبذولة وتوثيق النتاج العلمي الأكاديمي المتخصص، رغبة من هيئة التحرير في أن تكون المجلة منفذاً لنشر الإنتاج العلمي الذي سيقدم في المجالس العلمية، ولجان الترقية، وفقاً للقواعد والضوابط المنصوص عليها.

فمن خلال العدد **الرابع المجلد الأول مارس 2023م** نهديكم أعزاءنا القراء والبحاث عدداً من البحوث والدراسات في مجالات متنوعة والتي تشكل حلقة مهمة في السلسلة البحثية لتعميق المعرفة لديكم ودعم مصادركم.

وفي الختام نتقدم بالشكر والامتنان إلى كل من ساهم وعمل على استمرار هذه المجلة العلمية، وندعو جميع الباحثين المهتمين بالعلوم والتكنولوجيا إلى تقديم نتاجهم العلمي للنشر فيها.

أسرة المجلة

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المحتويات

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المحتويات

Use of plant essential oils in fish aquaculture as growth promoters: A review.

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استخدام الزيوت العطرية النباتية كمحفزات للنمو في تربية الأحياء المائية (دراسة مرجعية)

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الملخص:

في تربية الأحياء المائية، يتم استخدام العديد من الإضافات الطبيعية للأعلاف لتحقيق استدامة الأسماك المستزرعة والحفاظ على حالة صحية جيدة، ولتحفيز المناعة، والوقاية من أمراض الأسماك المستزرعة بنمو أفضل وتكلفة أقل. تجذب الزيوت العطرية النباتية الانتباه من بين هذه المنتجات الطبيعية كإضافات علفية، حيت تعتبر آمنة للحيوانات والبشر والبيئة. إلى جانب ذلك، استخدمت العديد من الزيوت النباتية كمصدر جزئياً أو كلياً ليحل محل زيت السمك لتقليل من تكلفة وجبات الأسماك، مما يؤدي إلى تحسين نمو وصحة الأسماك والبقاء على قيد الحياة بعد الإصابة البكتيرية. تقدم هذه المقالة فكرة عن الدراسات الحديثة التي تستخدم الزيوت العطرية النباتية كمضافات علفية في العديد من أنواع الأسماك المستزرعة باختلاف وزن الجسم والجرعة والمدة.

الكلمات المفتاحية: *الزيوت العطرية، النمو، تربية الأحياء المائية، السمك، الأعلاف.*

Abstract:

In aquaculture, various natural feed additives are used to achieve farmed fish sustainability and maintaining a good health status, stimulate immunity, and prevent diseases of the cultured fish with better growth and less cost. Plant essential oils attract attention among these natural products as feed additives, as they are considered to be safe for animals, humans, and the environment. Besides that, many plant oils have used as a source partially or completely replace fish oil for reducing the cost of fish meals, yielding improved fish growth, fish health and survival after bacterial infection. The present article gives an idea about the recent studies that utilize plant essential oils as feed additives in many cultured fish species with different initial body weight, dose and duration.

Keywords: *Essential oils, growth, aquaculture, fish, feed additive.*

Abbreviations:

CF, Condition factor; **FCR,** Feed conversion ratio; **FW,** Final weight; **GIFT,** Genetically improved farmed tilapia; **SGR,** Specific growth rate; **WG,** Weight gain.

Symbols:

↑ indicates increase, ↓ indicates decrease, ↔ indicates no change.

Introduction:

Aquaculture is one of the fastest developing growth sectors in the world. Therefore, it is an important commercial activity in many countries (Sahu et al., 2008; Mohamed et al., 2018).The main objective of aquaculture is maximized growth with fewer costs. Therefore, nutrition of fish is considered one of the most factors that can influence the growth rate and health status of the cultured fish (Farahi et al., 2010). Recently, the global aquaculture production has increased vastly in the last years for protein requirement of humans. With the development of aquaculture, the problems and threats started in increasing. Fish are exposed to several infectious diseases which can reduce the fish yield (Erguig et al., 2015; Syahidah et al., 2015). The use of antibiotics and chemotherapeutic agents for controlling diseases can reduce the mortality and improve the growth rates; however, they are often an expensive and unhealthy way to treat any disease (Lauzon et al., 2010). The excessive use of antibiotics as immunostimulants has led to an increase in the antibiotic resistance by microorganisms, which causes problems when treating microbial infections in an aquaculture setting (Ringø et al., 2010; Bulfon et al., 2015). Moreover, the antibiotic and chemotherapeutic residues can remain in fish tissues, which may threaten the health of human consumers and cause pollution of the aquatic environment (Biswas et al., 2010; Bulfon et al., 2015; Syahidah et al., 2015; Kadak and Salem, 2020; Salem et al., 2021). In this paper, we will review recent studies that utilize essential oils in fish culture. Data were obtained from different scientific literature databases such as Research Gate, Pub Med, Google Scholar and Web of Science and Science Direct. This scientific review were included researches reported and published from 2011- 2022, and around 68 references.

Health benefits of plant essential oils in aquaculture

In the past decade, the application of medicinal plants or their phytochemicals as alternative medicines to chemical medicines in the aquaculture sector have received immense attention and increased significantly for different activities as antimicrobial (Reverter et al., 2014; Erguig et al., 2015), antioxidant (Gabor et al., 2012; Syahidah et al., 2015; Sönmez et al., 2015; Salem et al., 2021). Also act as immunostimulants (Alishahi et al., 2010; Awad et al., 2013; Elbesthi et al., 2020), appetite stimulator, ameliorative digestibility (Lee and Gao, 2012; Santoso et al., 2013), growth promoters (Banaee et al., 2011; Asadi et al., 2012), increasing survival rates (Sankar et al., 2011; Hwang et al., 2013). Besides that, many plant oils have used as a source partially or completely replace fish oil for reducing the cost of fish meals (Hixson et al., 2014; Dinardo et al., 2020; Chung et al., 2021), yielding improved fish growth, fish health and survival after bacterial infection (Ahmadifar et al., 2011; Swathy et al., 20.18; Ghafarifarsani et al., 2021). Recently, many studies have been replaced chemical drugs with plant oils in the aquaculture industry (Toyes-Vargas et al., 2020; Yan et al., 2020; Betancor et al., 2021; Willor et al., 2021). The use of plant oils in aquaculture could also reduce treatment costs associated with the side effects of chemotherapeutic and antibiotic use (de Souza et al., 2019; Mu et al., 2020; Magouz et al., 2021). Hence, the use of plant oils as supplemented diet in aquaculture has been successful because they are available, have fewer side effects, are cheaper, safer, biodegradable, biocompatible and eco-friendly (Bulfon et al., 2015; Junior et al., 2018; Taştan and Salem 2021).

Table 1. Effects of dietary plant essential oils supplementation on growth in fish.

plant essential oil	Fish species and initial body weight	Dose and duration		Notable results	References
Encapsulated combination of carvacrol and thymol	Rainbow trout (*Oncorhynchus mykiss*) 8.4 ± 0.1g	2.0 and 3.0 g kg^{-1} for 45 days		↑ FW ↑ WG ↑ SGR ↑ FCR	Ahmadifar et al. (2011)
Canola Oil	Yellowtail kingfish (*Seriola lalandi*) 95.6 ± 0.1g	50, 100% for 34 days		↓ growth	Bowyer et al. (2012)
Carvacrol and thymol	Rainbow trout (*Oncorhynchus mykiss*) 113.0± 10.4 g	1 g/kg for 8 weeks		↔ Growth	Giannenas et al. (2012)
Lippia alba	Silver catfish (*Bagrus bajad*) 22.93 ± 0.75 g	0.25, 0.5, 1.0 or 2.0 ml kg^{-1} for 60 days		↔ Growth	Saccol et al.(2013)
Thymol–carvacrol	Great sturgeon (*Huso huso*) Linnaeus, 1758) 43.6±1.6 g	0, 1.0, 2.0, and 3.0 g/kg for 60 days		↑ Growth	Ahmadifar et al.(2014)
Peanut Oil	Mozambique Tilapia Juveniles (Oreochromis mossambicus) 6.36±0.19 g	50% and 100% for 60 days		↑ WG ↑ FCR	Demir et al.(2014)
Palm oil	Young yellowtail (*Seriola quinqueradiata*) 236 g	40% for 36 weeks		↑ Feed intake	Khaoian et al.(2014)
Camelina (*Camelina sativa*) oil	Atlantic salmon (*Salmo salar*) 242 ± 46 g	full replacement of fish oil	For 16 weeks	↔ Growth	Hixson et al. (2014)
	Rainbow trout (*Oncorhynchus mykiss*) 44.9 ± 10 g		For 12 weeks	↑ Growth	
	Atlantic cod (*Gadus morhua*) 14.4 ± 1.6 g		For 13 weeks		
Encapsulated combination of carvacrol and thymol	Great sturgeon (*Huso huso*) 43.6 ± 1.6 g	1, 2 and 3 g kg^{-1} for 60 days		↑ Growth	Ahmadifar et al. (2014)
Oregano	Yellowtail Tetra (Astyanax altiparanae) 1.46±0.09 g	0.0, 0.5, 1.0, 1.5, 2, and 2.5 g/kg for 90 days		↑ Growth	De Moraes França Ferreira et al. (2014)

Linseed oil	Darkbarbel catfish (*Pelteobagrus vachelli*) 0.99 ± 0.01 g	2 and 4% for 46 days	↔ Growth	Li et al. (2014)
Sage (*Salvia officinalis*) oil	Rainbow trout (*Oncorhynchus mykiss*) 5.06 ± 0.11 g	500, 1,000 and 1,500 mg kg^{-1} for 60 days	↑ WG ↑ SGR	Sönmez et al.(2015a)
Mint (*Mentha spicata*) oil			↓ WG ↓ SGR ↑ FCR	
Thyme (*Thymus vulgaris*) oil			↑ WG ↑ SGR	
Sweet Orange Peel (*Citrus sinensis*)	Mozambique tilapia (*Oreochromis mossambicus*) 0.91 ± 0.03 g	0.1, 0.3 and 0.5% for 90 days	↑ WG ↑ SGR ↑ FCR	Acar et al. (2015)
1,8-cineole, carvacrol or pulegone	Rainbow trout (Oncorhynchus mykiss) 13.3 ± 0.08 g	0.5, 1, and 1.5% for 60 days	↑ Growth	Sönmez et al.(2015b)
Citrus limon peels essential oil	Mozambique tilapia (*Oreochromis mossambicus*). 12.87 ± 0.18 g	0.5, 0.75 and 1% for 60 days	↔ WG ↔ SGR ↔ FCR	Baba et al. (2016)
Lime basil	Red drum (*Sciaenops ocellatus*) 17.75 ± 0.1 g	0, 0.25, 0.5, 1.0, and 2.0 g/kg diet for 7 week	↔ Growth	Sutili et al. (2016)
Peanut Oil	Sea bream *Diplodus vulgaris* 10.37 ± 0.25 g	50%and 100% for 8weeks	↔ Growth	Kesbiç et al. (2016)
Clove Basil (*Ocimum gratissimum*) and ginger (*Zingiber officinale*)	GIFT Tilapia (*Oreochromis niloticus*) 1.84 ± 0.52 g	0.5, 1.0 and 1.5% for 55 days	↑ Growth	Brum et al. (2017)
oregano (*Origanum onites* L.) essential oil	Rainbow trout (*Oncorhynchus mykiss*) 26.05 ± 0.15 g	0.125, 1.5, 2.5 and 3.0 mL kg^{-1}) for 90 days	↑ Growth	Diler et al. (2017)
Citrus limon peel essential oil	Ningu (Labeo victorianus) fingerlings 21.0 ± 2.4 g	10, 20, 50 and 80 g kg−1 for14 days	↑ Growth	Ngugi et al. (2017)
Grape (*Vitis vinifera*) seed oil	Rainbow trout (*Oncorhynchus mykiss*) 30 g	250, 500, 1,000 mg/kg feed for 60 days	↑ Growth	Arslan et al. (2018)
centary oil (*Hypericum perforatum*)	common carp (Cyprinus carpio)	5 and 10 g/kg for 60 days	↑ SGR	Acar et al. (2018)

Limonene and thymol	Nile tilapia (*Oreochromis niloticus*)	1.5 ± 0.0 g 1.5 ± 0.1 g	limonene at 200, 400, and 600 mg kg^{-1} thymol was 250 and 500 ppm	for 63 days	↑ Growth	Aanyu, Betancor, and Monroig, (2018)
Oregano	Nile tilapia (*Oreochromis niloticus*) 13.21 ± 1.71 to 14.24 ± 1.18 g		0.0, 1.0, and 2 mL/kg for 10 weeks		↑ Growth	El-Hawarry et al. (2018)
***Citrus sinensis* peel oil**	Rainbow trout (*Oncorhynchus mykiss*) 4.48 ± 0.03 g		0.5, 1, and 3 g kg−1 For 90 days		↑ Growth	Gültepe (2018)
pomegranate seed oil	Rainbow trout (*Oncorhynchus mykiss*)		0.5% , 1.00% , and 2.00% for 60 day		↑ Growth	Acar et al. (2018)
Cinnamaldehye and thymol	Nile tilapia (*Oreochromis niloticus*) 10.2 ± 0.06 g		1 and 2 mL/kg diet for 75 days		↑ Growth	Amer, Metwally and Ahmed, (2018)
cannabis seed oil (*Cannabis sativa*)	Rainbow trout (*Oncorhynchus mykiss*) 17,23±0,39 gr		0.5, 1% and 2% for 60 days		↑ Growth	Saleh (2019)
juniper berry oil	common carp (*Cyprinus carpio*) 3.07 ± 0.15 g		5 and 10 (JBO-10) ml/kg for 60 days		↑ Growth	Kesbiç (2019a)
Cinnamon Oil (Cinnamomum verum)	Rainbow Trout (*Oncorhynchus mykiss*) 10,68±0,35		1 , 2 , 4 and 10 mL/kg for 60 days		↑ Growth	Kesbiç (2019b)
Citrus. aurantium essential oil)	Silver catfish (*Rhamdia quelen*) 1.96 ± 0.4 g		0.25, 0.5, 1.0, and 2.0 ml kg−1 diet for 60 days		↑ Growth	Lopes et al. (2019)
Soybean oil	Nile tilapia (*Oreochromis niloticus*) 425.33 ± 32.37 g		15, 30, 45 and 60 g kg^{-1} for 50 days		↑ FW ↑ WG	Godoy et al. (2019)
***Ocimum basilicum* essential oil**	Nile tilapia (*Oreochromis niloticus*) 12.13 ± 0.11 g		0.25, 0.5, 1.0 and 2.0 kg diet^{-1} for 45 days		↑ Growth	de Souza et al.(2019)
***Thymus vulgaris* essential oil**	Rainbow trout (*Oncorhynchus mykiss*) 10g		0.5 mg kg $^{-1}$ feed for 2 months		↑ FW ↑ WG ↑ SGR ↑ FCR	Zargar et al. (2019)
Camelina (*Camelina sativa*) oil	GIFT Tilapia (*Oreochromis niloticus*) 28 ± 6 g		6% for 8 weeks		↔ Growth	Toyes-Vargas et al.(2020)

Bergamot (Citrus. bergamia) peel oil	Nile tilapia (*Oreochromis niloticus*) 2.57 ± 0.06 g	0.5%, 1.0%, and 2.0% for 8 weeks	↑ Growth	Kesbiç et al. (2020a)
essential oil from the leaves of Monterey cypress (Cupressus macrocarpa)	common carp (Cyprinus carpio) 7.86 ± 0.15 g	0.5%, 0.75% and 1% for 60 days	↑ Growth	Kesbiç et al. (2020b)
Citrus × latifolia essential oil)	Tambaqui (Colossoma macropomum 2.21 ± 0.5 g)	0.25, 0.5, 1.0, and 2.0 ml essential oil kg−1 diet for 60 days	↑ Growth	Lopes et al. (2020)
Bitter lemon (C. limon) peels	Nile tilapia (*Oreochromis niloticus*) 16.42 ± 0.059 g	0.75% and 1% for 60 day	↑ Growth	Mohamed et al. (2020)
Aloysia triphylla	Nile tilapia (*Oreochromis niloticus*) 10.79 ± 0.02 g	0.25, 0.50, 1.00 and 2.00 ml kg diet^{-1} for 45 days.	↑ FW ↑ WG ↑ SGR	de Souza et al. (2020)
Rosemary essential oil	Young great sturgeon (*Huso huso*) 130.94 ± 5.28 g	0.01, 0.1, 1 and 2% for 8 weeks	↔ Growth	Ebrahimi et al. (2020)
Oregano (*Origanum vulgare* L.) essential oil	Common carp (*Cyprinus carpio* L.) 20.3 ± 0.8 g	5, 10, 15 and 20 g/kg diet for 2 months	↑ FW ↑ WG ↑ SGR ↔ FCR	Abdel-Latif et al.(2020)
	Sea bass (*Dicentrarchus labrax*) 80.83 ± 2.11 g	100 and 200 ppm for 60 days	↑ Growth	Dinardo et al. (2020)
Hot pepper (Capsicum sp.) oil	rainbow trout (Oncorhynchus mykiss) 7.20 ± 0.57g	1‰ 2‰,4‰ and 6‰ for 60 days	↑ Growth	Parrino et al. (2020)
Menthol essential oil	Nile tilapia (*Oreochromis niloticus*) 31.11 ± 1.14 g	0.25% for 30 days	↑ FW ↑ WG ↑ SGR ↓ FCR	Dawood et al. (2020)
Corn oil, tea oil, olive oil, rice oil **Sunflower oil**	Hybrid grouper (♀ *Epinephelus fuscoguttatus* × ♂*E. lanceolatus*). 15.09 ± 0.01 g	5% for 8 weeks	↔ WG ↔ SGR ↓ WG ↓ SGR	Yan et al. (2020)

Oregano (Origanum vulgare L). essential oil	Nile tilapia (*Oreochromis niloticus*) 11.5 ± 0.4 g	1, or 2 ml/kg for 12 weeks	↑ FW ↑ WG	Shourbela et al. (2021)
Ginger *(Zingiber officinale)*	Nile tilapia (*Oreochromis niloticus*) 7.78 ± 0.10 g	0.5,1.0, 1.5 and 2.0 ml kg diet $^{-1}$ for 60 days	↑ Growth ↑ FCR	Chung et al. (2021)
Soybean oil	Brown trout (*Salmo trutta*) 10.2 ± 0.2 g	33, 67 and 100% for 90 days	↔ Growth	Mehtap Bayır. (2021)
Transgenic (*Camelina sativa*)	European sea bass (*Dicentrarchus labrax* L.) 16.7 ± 0.92 g	5.7, 7.4 and 8.2% for 4 months	↓Growth	Betancor et al. (2021)
Nettle (Urtica dioica) seed oil	Rainbow trout (*Oncorhynchus mykiss*) 22.39 ± 0.1 g	0.5, 1% and 2% for 60 days	↔ Growth	Lakwani (2021)
Menthol essential oil	Nile tilapia (*Oreochromis niloticus*) 15.11 ± 0.06 g	0.1, 0.2, 0.3, and 0.4% for 8 weeks	↑ FW ↑ WG ↑ SGR ↑ FCR	Magouz et al. (2021)
***Lippia sidoides* essential oils**	Tambaqui (*Colossoma macropomum*) 14.02 ± 1.00 g	0.625 and 1.25 g/kg	For 60 days ↔ Growth	Monteiro et al. (2021)
***Ocimum gratissimum* essential oils**		1.25 and 5.0 g/kg		
***Zingiber officinale* essential oils**		1.25 and 5.0 g/kg		
Thyme essential oil	Rainbow trout (*Oncorhynchus mykiss*) 20.77 ± 0.08 g	1% for 30 days	↑ FW ↑ WG ↑ SGR ↑ FCR	Ghafarifarsai et al.(2021)
Thymol and carvacrol	Nile tilapia (*Oreochromis niloticus*) 8.00 ± 0.01 g	300 mg/kg for 8 weeks.	↔ Growth	Ning et al. (2021)
Essential Oil from the Bitter Orange (*Citrus aurantium*)	common carp *Cyprinus carpio* 1.94 ± 0.05 g	0.25%, 0.50%, 1% and 1.5% for 60 days	↑ Growth	Acar et al. (2021)

blend of liquid essential oils containing (carvacrol, oregano, 1,8 cineol, thymol, pinene, pinene β, limonene, and propylene glycol)	Nile tilapia (*Oreochromis niloticus*) 19.6 ± 0.51 g	0.25, 0.5 and 1 ml kg $^{-1}$ for 60 days	↑ FW ↑ WG ↑ SGR	Magouz et al. (2022)
Black mustard (*Brassica nigra*) seed oil	Rainbow trout (*Oncorhynchus mykiss*) 22.39 ± 0.1 g	0.5, 1% and 2% for 60 days	↑ Growth	Lakwani et al. (2022)
savory (*Satureja hortensis*) essential oil	Caspian roach (*Rutilus caspicus*) 2.29 ± 0.07 g	100, 200, or 400 mg/kg for 60 days	↓Growth	Ghafarifarsai et al. (2022)
Cinnamon *Cinnamomum cassia* essential oils	silver catfish (*Rhamdia quelen*) 6.62 ± 0.28 g	1.0 mL for 60 days	↑ FW ↑ WG	Bandeira Junior et al. (2022)
***Dracocephalum kotschyi* essentia l oil**	Rainbow trout (*Oncorhynchus mykiss*) 55 ± 5.6 g	0.2, 0.25 and 0.3 mg/kg for 60 days	↔ Growth	Hafsan et al. (2022)
thyme essential oil	Rainbow trout (*Oncorhynchus mykiss*) 11.92 ± 0.06 g	1% and 2% for 60 days	↑ Growth	Yousefi et al. (2022)
oregano (*Origanum vulgare*) essential oil	Black Sea salmon, *Salmo labrax* 3.52±0.01 g	50, 100, 200, and 400 mg kg–1 for 90 days	↔ Growth	Özel et al. (2022)
carvacrol , thymol and cinnam aldehyde acid	Nile tilapia (*Oreochromis niloticus*, Thai strain) 22.86 ± 0.46 g	3.3, 6.7, and 10 g kg–1 die for 60 days	↑ Growth	Zaminhan-Hassemer et al.(2022)

Overview on the use of plant essential oils in aquaculture

In the present paper, we observed that plant essential oils have great potential to be used in aquaculture as feed additives. According to studies reviewed (Table -1), we can infer that plant essential oils has different effects on growth improvement in growth performance could be related to many factors such as dose-dependent and appear to be species-specific and nutrient digestibility, nutrient absorption, improved digestive enzymes and maintaining the function and structure of the gastrointestinal of fish, leading to an increased digestive capacity of the gut (Chung et al., 2021). Also, some studies

reported growth retardation after the plant oils supplementation. The reason behind this inference is that some plant oils leading to a decreased digestive capacity of the gut by inhibitory effects the activities of digestive enzymes secretion or adversely affect feed palatability (Yan et al., 2020).

To avoid such undesirable consequences, further studies should be conducted taking into mentioned the above possibilities while selecting the plant oils supplementation and administration dose.

Conclusion:

Plant essential oils provide enormous beneficial effects in aquaculture by improving appetite, stimulating immune responses, microbial balance, antioxidative capacity, and disease resistance of cultured fish. At the same time, plant essential oils provide growth-promoting and feed utilization effects. A comprehensive review illustrates that the primary determinants of plant essential oils efficacy in cultured fish are the concentration, the oil's source, and duration of administration. This review article indicates clearly that plant essential oils have beneficial effects on aquatic animals' performances, and can feasibly replace chemotherapies and antibiotics for clean, healthy, and sustainable aquaculture.

Recommendations:

It is recommended to use natural products such as plant oils in developing alternative dietary supplements that enhance growth performance and the health of cultured fish because these products are inexpensive, safer, effective, can be easily prepared, and have few side effects on animals and the environment. Also, it is recommended strongly to be further studied dosage optimization in terms of ideal dose, duration, mode of administration and mechanisms of action on aquatic animals. The use of medicinal plants in aquaculture will continue to grow at a confident pace. Commercially available plant oils will be strongly recommended in the global market for large-scale use in aquaculture.

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