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THE OMEGA-3 AND OMEGA-6 FATTY ACIDS POTENTIAL OF PUMPKIN, CANDLENUT AND NUTMEG SEEDS AS PHYTOADDITIVE FOR POULTRY. A REVIEW

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Abstract

Fatty acids are important constituents of plants and known to possess antimicrobial activities. The biological activity and the possibility of the therapeutic of fatty acids of plant extracts as antimicrobial agents is reviewed. Pumpkin seed, candlenut, and nutmeg are rich in omega-3 and omega-6 fatty acids that possess antimicrobial activities, have potential antioxidant, antiinflammatory, antihyperlipidemic properties in poultry feeding. Pumpkin seed, candlenut, and nutmeg are a rich source of fixed and essential oil, triterpenes, and various types of phenolic compounds. The literature about the benefits of plants seed potency as an alternative phytoadditive for poultry was rare. This article provides an overview that on the potency and biological activity of the omega-3 and omega-6 from pumpkin seed, candlenut, and nutmeg as a basis for exploring it as a phytoadditive for poultry. The method used is the synthesis matrix. From the review of the article, it was concluded that pumpkin seed, candlenut, and nutmeg have the potential to be developed as an alternative feed for poultry, and have bioactive constituents that promote health.

Key words: *antibacterial, omega-3 fatty acid, omega-6 fatty acid, phytoadditive, poultry.*

INTRODUCTION

The common fatty acids in plants are saturated or simple unsaturated compounds of C16 or C18 chain length. Palmitic acid (C16) is the major saturated acid in leaf lipids and some seed oils, while stearic acid (C18) is a major saturated acid in seed fats in several plant families. Unsaturated acids based on C16 and C18 are widespread in leaf and seed oils. The tri-unsaturated linolenic acid, linoleic and oleic acids are common (Harborne and Baxter, 1993), and according to Harwood (1980), quantitatively, the major fatty acids in plant are palmitic, linoleic and, in particular, α-linolenic acids.

Many fatty acids are known have antibacterial and antifungal properties (Russel, 1991). The antibacterial properties of antimicrobial lipids have been known since long, when it was shown that fatty acids, a class of antimicrobial lipid, inhibited growth of the *Bacillus anthracis* pathogen that causes anthrax (Thormar, 2010). Antimicrobial lipids such as fatty acids and monoglycerides are promising antibacterial agents that destabilize bacterial cell membranes, causing direct and indirect inhibitory effects (Yoon et al., 2018).

Fatty acids are released from lipids by the action of enzymes to become free fatty acids, which have potent biological activities (Desbois & Smith, 2010). Fatty acids (FAs) are potential therapeutic antimicrobial agents due to their potency, broad spectrum of activity and lack of classical resistance mechanism against the actions of these compounds (Desbois, 2012). Various long chain polyunsaturated FAs, which are found naturally at high levels in many marine organisms, have been shown to exert highly potent activity against Gram-positive bacteria, including eicosapentanoic acid (EPA; C20:5n-3) (Desbois, 2013) docosahexanoic acid (DHA; C22:6n-3) (Huang & Ebersole, 2010), γ- linoleic acid (GLA; C18:3n-6) and dihomo- γ - linolenic acid (DGLA: C20:3n-6). Similar to many other PUFAs, eicosapentaenoic acid (EPA; C20:5 n-3) exerts potent effects against Gram-positive species, including human pathogens *Bacillus cereus* and *S. aureus*.

Long-chain unsaturated fatty acids, such as linoleic acid, show antibacterial activity and are the key ingredients of antimicrobial food

additives and some antibacterial herbs (Zheng et al., 2005).
Long-chain unsaturated fatty acids are bactericidal to important pathogenic microorganisms, including Methicillin-resistant *Staphylococcus aureus* (Farrington et al., 1992), *Helicobacter pylori* (Sun et al., 2003), and *Mycobacteria* (Seidel & Taylor, 2004). These antibacterial actions of fatty acids are usually attributed to long-chain unsaturated fatty acids including oleic acid, linoleic acid, and linolenic acid, while long-chain saturated fatty acids, including palmitic acid and stearic acid, are less active (Sun et al., 2003; Seidel & Taylor, 2004).
Pumpkin, scientific name *Cucurbita moschata* is part of the Cucurbitales order, Cucurbitaceae family and *Cucurbita* genus that has long been applied in Asia for medicinal goals (Call et al., 2006). Pumpkin seeds has many nutrients including polysaccharides, essential fatty acid, carotenoids, mineral, active proteins, and essential amino acids. The seeds have a high nutritional value (Fokou et al., 2004). That seeds had medicinal properties for their biological effects such as antimicrobial activities (Abd EI-Aziz & Abd EI-Kalek, 2011).
Candlenut, scientific name *Aleurites moluccana*, belongs to euphorbiaceae family and grows widely in tropical and sub tropical regions. It is also known as Buah Keras in Malaysia, Kemiri in Indonesia, Indian Walnut in India, and Kukui in Hawaii. It is used in folk medicine to treat stomach in children, bad breath, skin sores, fever, headaches, tumors, diarrhoea, asthma and helps in rejuvenating the body after poisoning.
Candlenut seeds was classified as a type of stone fruit because they have physical characteristics of hard skin and shell shape, then the outer surface was roughly curved (Sinaga, 2016). Besides the consumption of core candlenut seeds is very large (Permana et al., 2017). Candlenut is a common spice that contains high levels of fatty acids.
Nutmeg, is dried kernel of broadly ovoid seed of *Myristica fragrans* Houtt (Family: Myristicaceae). It is widely used as spices in culinary preparations and in alternative medicine as aphrodisiac (Tajuddin et al., 2003), memory enhancer, antidiarrhea (Grover et al., 2002). This plant produces two spices: mace and nutmeg. Nutmeg is the seed kernel inside the fruit and mace is the red lacy covering on the kernel. Myristica species are natives of Moluccas, indigenous to India, Indonesia and Sri Lanka and now cultivated in many tropical countries (Pal et al., 2011). About 30-55% of the seed consists of oils and 45-60% consists of solid matter including cellulose materials.
Nutmeg seeds supplementation may improve blood lipids, ameliorate oxidative stress and this may be due to interactive or additive effects of the numerous bioactive constituents (Thomas & Krishnakumari, 2016). The medicinal use of nutmeg and its use as a spice suggest that it contains some constituents which are responsible for the reported biological activities (Al-Jumaily et al., 2012). Nutmeg extract ameliorates hyperglycemia and abnormal lipid metabolism in animal models (Arulmozhi et al., 2007).
This paper provides a comprehensive overview of various aspects of the species of pumpkin seeds, candlenut, and nutmeg in relation to its potential, which will be used as a benchmark for its use as phytoadditive.

MATERIALS AND METHODS

The technique and instrument used to present a comprehensive overview of the potential of pumpkin seeds, candlenut, and nutmeg is a synthesis matrix. The process is to integrate the results of the analysis of articles based on the similarities and differences of each article. Then make conclusions based on the identification and classification of the potential topic of pumpkin seeds, candlenut, and nutmeg (Ramdhani, et al., 2014). The synthesis matrix is a table/diagram that allows researchers to group and classify different arguments from several articles and combine different elements to get an impression / conclusion on the whole article in general (Murniati et al., 2018).

RESULTS AND DISCUSSIONS

The synthesis of research articles on the antimicrobial lipid potency of pumpkin seed, candlenut, and nutmeg shown in Tables 1, 2, and 3.

Table 1. Omega-3 and Omega-6 Potency of Pumpkin Seed

Descriptions/Issues of the Plant Seeds	References (Author, Year)
- seed oil showed that predominant unsaturated were linoleic (42%) and oleic (38%), - while the major saturated were palmitic (12,7%) and stearic (6%)	Esuoso et al., 1998
- oil showed the saturated fatty acids content was 27.73% and consisting of 16.41% palmitic acid and 11.14% stearic acid - unsaturated fatty acids value was 73.03% and consisting of 18.14% oleic acid and 52.69% linoleic acid	Alfawas, 2004
- Up to 60.8% of the pumpkin seed oil is from the fatty acids, oleic (up to 46.9%), linolenic (up to 40.5%) and palmitic and stearic (up to 17.4%)	Nakiae et al., 2006
- Excellent source of protein, minerals, vitamins and unsaturated fatty acids	Juranovic et al., 2003; Siegmund & Murkovic, 2004; Glew et al., 2006
- highly nutritional and rich nutraceutical components such as unsaturated fatty acids especially palmitic acid, stearic acid, oleic acid and linoleic acid	Stevenson et al., 2007
- The predominant fatty acids were stearic, palmitic, oleic acid and linoleic acid	Raharjo et al., 2011
- showed a high content of unsaturated fatty acids and the dominant fatty acids were palmitic, stearic, oleic, and linoleic acids - the seeds were well endowed in crude oil, protein, carbohydrates and crude fibre. - the oil contained unsaturated fatty acids and α- tocopherol	Karanja et al., 2013
- Those essential fatty acids are belonging to the ω-6 and ω-3 family which exert amazing nutritional functions and play important role in many metabolic pathways	Miura, 2013
- Polyunsaturated linoleic fatty acid was the predominant fat component in pumpkin seed oil. - In saturated fatty acids, palmitic and stearic acids predominated. - The antioxidant activity increased proportionally with the phenolic content	Kulaitienė et al., 2018

Pumpkin seed, candlenut and nutmeg have been used as an alternative feed ingredient in poultry production.

Pumpkin seeds proximate analysis revealed a higher crude protein, moisture and mineral content (Nworgu et al., 2007).

Hajati et al. (2011) indicated that supplementation of diets with 5 g pumpkin seed oil/kg dry matter in corn soybean meal-wheat based diet can be profitable because it reduced broiler chickens mortality and it did not have any adverse effect on the performance of birds.

Table 2. Omega-3 and Omega-6 Potency of Candlenut

Descriptions/Issues of the Plant Seeds	References (Author, Year)
- This plant possesses the antimicrobial activity against *S. typhi*, *Vibrio cholera*, and *E. coli*, lowering cholesterols and lipid absorption	Pedrosa et al., 2002
- anti-inflammatory and antipyretic	Niazi et al., 2010
- also as an analgesic	Quintao et al., 2011
- seed contain high proportions of polyunsaturated fatty acid (PUFA) such as ω-3, ω-6, and ω-9	Martin et al., 2010; Rohaida et al., 2014
- safe for internal uses, and its extract also has the potential to treat selected autoimmune inflammatory diseases by inhibiting the growth of the bacterial triggers	Mpala et al., 2017
- possess the antimicrobial activity against *S. typhi*, *Vibrio cholera*, and *E. coli*, lowering cholesterols and lipid absorption, anti-inflammatory, antipyretic, and an analgesic	Pedrosa et al., 2002; Niazi et al., 2010
- Based on spectroscopic analysis, these isolate of saponins may be predicted as triterpenoid saponins, diosgenin	Amalia et al., 2020

Table 3. Omega-3 and Omega-6 Potency of Nutmeg

Descriptions/Issues of the Plant Seeds	References (Author, Year)
- two types of oils extracted from the nutmeg seed, the essential oil and the fixed oil called the nutmeg butter	Forrest & Heacock, 1972
- As a plant seed, myristic acid is the main part of fat. Phenylalanine is the dominant amino acid in nutmeg	Pathak & Ojha, 1957; Maya et al., 2006
- the fatty acid composition of the triacylglycerol, the major lipid component, were myristic, palmitic, lauric, petroselinic, and stearic acids	Niyas et al., 2003
- Scientists reported that nutmeg have hypolipidemic and hypocholesterolemic effects, antimicrobial, antidepressant, aphrodisiac, memory-enhancing, antioxidant, and hepatoprotective properties	Jaiswal et al., 2009
- The major constituents fatty oil of Indian nutmeg were oleic acid, arachidic acid, palmitic acid - The major constituents fatty oil of Sri Lankan nutmeg were myristic acid and palmitic acid	Naher et al., 2013
- The major biological compounds in the methanol extract were 9,12-Octadecadienoic acid methyl ester, cyclododecyne, and octadecanoic acid, - the hexane extract constituents were margarinic acid, oleic acid, and 9,12-octadecadienlol.	Anaduaka et al., 2020
- Nutmeg has been reported to have antioxidant, anti-tumor, and antibacterial effects, and more	Olaleye et al., 2006; Acuña et al., 2016; Le et al., 2017; Zhang et al., 2016; Gupta et al., 2013
- Nutmeg extract posses antimicrobial antioxidant and anticancer activity. It support the fact that nutmeg extract can be used as future drug	Chakraborty et al., 2015
- Antioxidant activity of the mace essential oil was examined, β-carotene in linoleic acid and percent inhibition in linoleic acid (67.9 %) system.	Din et al., 2021
- Nutmeg seeds may improve blood lipids, ameliorate oxidative stress and this may be due to interactive or additive effects of the numerous bioactive constituents	Thomas and Krishnakumari, 2016

Pumpkin seed oil feed trials on broiler birds have also proved to lower bird mortality, as well as reduced cholesterol and triglyceride concentrations in blood plasma. Mart'ınez et al. (2010a, b) reported that 10% inclusion of pumpkin seed meal in broiler chicken diets served as a suitable substitute for soya bean meal as it enhanced the reduction in excessive abdominal fat, leading to increased production performance and improved organoleptic meat quality.

The inclusion of 0, 33, 66 and 100 g/kg of *Cucurbita moschata* in broiler diets, partially replacing soybean meal and vegetable oil, improved live performance and edible portions yield. In addition, abdominal fat and serum levels of harmful lipids were reduced, whereas serum levels of beneficial lipids increased. There was no effect on meat sensory quality (Aguilar et al., 2011).

Tabari et al. (2016) investigated that use of diet supplemented with pumpkin seed oil improved body weight and increased feed consumption in broiler chickens as a result of the positive effect of pumpkin seed oil on the intestine conditions leading to better digestion, absorption and utilization of nutrients and also due to the positive role of pumpkin seed oil on keeping a balanced microflora in the digestive tract.

That supplementary pumpkin seeds oils at a level 10 and 15 (g/kg) have a beneficial effect on productive trait, with no significantly effect of carcass characteristics, also pumpkin seeds oils in same levels reduced total plasma cholesterol concentrations and triglycerides in Japanese quail (Abbas et al., 2017). Pumpkin and flaxseed oils supplementation in feed mixtures of laying hens have a positive effect on the egg weight. Significantly higher average egg´s weight during experiment was found after dietary oils supplementation. Tendency of the highest egg´s weight was found after flaxseed oil supplementation (Herke et al., 2014).

Pumpkin seed extract is reported to be useful for immunomodulation, reproductive health, therapeutics over a wide range of disease conditions and stimulates metabolism of accumulated fats. Pumpkin seeds are a valuable source of protein and fat. Their bioactivity offers prospects for natural control of pathogenic/parasitic organisms, stimulate nutrition or enhance resistance to disease infections, and reduce abdominal fat and serum levels of harmful lipids, while increasing serum levels of beneficial lipids (Achilonu et al., 2018).

Broilers fed candlenut powder had significantly lower meat cholesterol content compared to basal diets. The use of candlenut powder as feed additive at the level of 1% is safely recommended to give better blood profile and reduce meat cholesterol content of broilers (Putri et al., 2018). Supplementing either treated or untreated candlenut meal at 2% level was shown to enhance the fatty acid profiles in broiler chickens meat (Rohaida et al., 2014). Supplementing 2.5% of various components of candlenut kernel in the diet did not improve growth performance, carcass yield, the chemical composition of broiler meat, and fatty acid composition of breast and thigh muscles of finishing broiler chickens (Rasid et al., 2019). The potential of the *A. mollucanas* nut as inhibitors of the growth of bacterial species associated with the onset of rheumatoid arthritis, ankylosing spondylitis and rheumatic heart disease (Mpala et al., 2017).

The *Myristica fragrans* seed meal supplementation at 0.25% enhanced the body weight gain, improved serum, and meat glutathione peroxidase and catalase, and reduced the broiler's meat cholesterol level and lipid oxidation (Adu et al., 2020). Supplementing either treated or untreated candlenut meal at 2% level was shown to enhance the fatty acid.

Supplementation 30% aqueous extract, 5% and 10% nutmeg increased weight and high profiles in broiler chickens meat (Rohaida et al., 2014).

That 30% aqueous extract, 5% and 10% supplemented nutmeg (*Myristical fragrance*) increased weight and high density lipoprotein (HDL) concentration and decreased blood glucose, low density lipoprotein (LDL), triglyceride and total cholesterol. Nutmeg diet exhibited significant anti-hyperglycemic in alloxan-induced diabetic rats (Oyindamola et al., 2017). The subchronic administration of 50, 100, and 200 mg/kg bw of nutmeg ethanolic extract did not cause the change of hematological parameters in rat (Bachri et al., 2017). *Myristica fragrans* ethanolic seed extract have hypolipidemic effect. *Myristica fragrans* ethanolic seed extract possess cardioprotective effect on experimentally induced cardio toxic myocardial infarcted rats (Thomas & Krishnakumari, 2016)

The antioxidant and antiinflammatory activity possessed by nutmeg could be helpful in preventing or slowing the progress of various oxidative stress-related diseases and inflamematory diseases (Sethi & Dahiya, 2018). The subchronic administration of 50, 100, and 200 mg/kg bw of nutmeg ethanolic extract did not cause the change of hematological parameters in rat (Bachri et al., 2017). Seed of *M. fragrans* confirmed the anti-inflammatory properties and suggested that it may have deleterious effects on haemopoiesis at high doses (Bamidele et al., 2011).

As presented in this review, there is enormous potential for employing antimicrobial lipids to combat bacterial infections for animal health and human health. Over the past few decades, significant progress has been made towards understanding the relative potency and spectrum of antibacterial activity for different classes of antimicrobial lipids, in turn identifying particularly promising phytoadditive candidates through biological investigations.

CONCLUSIONS

The general conclusion of this literature study is that pumpkin seeds, candlenut, and nutmeg have bioactive constituents that promote health. By understanding how antimicrobial lipids function and the critical role of molecular self-assembly, need to begin to design new strategies to enhance therapeutic performance. Recognizing the challenges of antibiotic-resistant bacteria and taking advantage of the low cost and abundant supply of antimicrobial lipids, there is excellent opportunity to further explore antimicrobial lipids as next-generation antibacterial agents for animal health and human health. All of these findings bring us to the new idea in developing and innovating nutraceuticals, pharmaceuticals, and products from pumpkin seeds, candlenut, and nutmeg as phytoadditive for poultry.

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