

Potential of Morinda (*Morinda citrifolia* L.) Products as Alternative to Chemical Additives in Poultry Diets

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THE CONCERN overuse of chemical substances in poultry feed has increased research into feed additives from plant origin. Morinda (*Morinda citrifolia*), a well-adapted and distributed shrub in the tropics, contains several substances which have nutritional and nutraceutical properties. These attributes justify the maximum utilisation of Morinda products in poultry feeding. Several products from the fruit, and leaves have antimicrobial, digestion enhancing, cholesterol reducing, immune modulation and heat stress reducing effects in poultry. Morinda fruit powder at 2 g/kg diet relieved heat stress in broilers; 30 g/kg reduced plasma cholesterol below 50% in broilers and 150 g/kg improved weight gain and feed efficiency in quails. Extracts from the fruit/leaf at 50 g/kg diet improved weight gain, feed efficiency, immunomodulation and reduced plasma cholesterol and *E. coli* count in broilers; at 1.5ml/bird/day and 50 g/kg diet improved weight gain and feed efficiency in broilers and quails, respectively. Morinda fruit granules at 200 g/kg was recommended as optimum for egg production in quails. There is however, need for more research into plant and animal factors and processing methods for maximum utilisation of these products in poultry diets. Morinda root has many functional properties but its use in poultry feeding is still limited and needs investigation in order to broaden our knowledge of the application of Morinda products in poultry nutrition.

Keywords: Chemical substances in feeds, Phytoadditives, Poultry performance, Product quality.

Introduction

Morinda (*Morinda citrifolia*), is a very important shrub of the family Rubiaceae native to India, but widely distributed from South-Eastern Asia to Australia [1, 2, 3]. It is also known as great morinda, nonu, Indian mulberry, and mengkudu in Malaysia, nhaut in Southeast Asia, painkiller bush or cheese fruit in Caribbean and canary wood in Australia [4]. The tree thrives well on saline, acidic and alkaline soils [2]. Despite its strong smell, Morinda fruit may be used as food during periods of famine or as staple food in some cultures [5]. In addition to its food uses, the fruit is known for its medicinal properties [4]. A wide range of Morinda products including fruit juice and powder (from ripe or unripe fruits), lotions, soaps, oil (from seeds), leaf powder (for encapsulation of pills) are now popular in the market. Extracts from Morinda bark and roots are important dyes in the textile industry [6]. Several biological compounds identified in different plant parts [7] have antimicrobial, cholesterol reducing, immune

and digestibility enhancing effects [8-14]. These properties may justify the use of Morinda products as alternative to commercial additives which are gradually banned on account of their public health concerns [15-17]. However, the use of Morinda in livestock feeding is still limited due to its strong smell and poor taste which makes most animals avoid the plant. Because chickens pick their feed mainly by seeing and feeling than scent or taste, Morinda products may have application as phytoadditives (PA) in poultry feeding. This paper reviews the composition (nutritional and nutraceutical) of Morinda plant parts, their current use in poultry feeding and prospects.

Composition of morinda plant parts

Nutritional composition

Because of its limited food value, most studies on the composition of Morinda have focused on its phytochemical constituents. Nutrient distribution differs between Morinda plant parts (fruit, leaves and roots) [18]. Morinda fruit is a poor to aver-

age source of protein but the protein has a good supply of isoleucine, glutamate and aspartate [19-21]. The fruit is an excellent source of potassium, sulphur, calcium, phosphorus, ascorbic acid and carotenoid and contains traces of selenium [22, 23]. Morinda seeds are rich sources of fatty acids mainly linolenic, oleic, stearic and lauric acids [18]. The pulp, a waste from Morinda juice extraction, is moderate in protein but high in fibre [24].

Common phytoconstituents and modes of action

Morinda plant parts (fruits, roots and leaves) contain different concentrations of several biological compounds (glycosides, polysaccharides, iridoids, alkaloids, lignans, trisaccharide fatty acid esters, anthraquinones, scopoletin, morindin, vitamins and minerals) [19, 21, 25-28] which are known to have antibacterial, antiviral, antifungal, cholesterol regulation and immune enhancing [9,12], antioxidant [29, 30] and digestion enhancing [10, 11,13, 14] properties. The antimicrobial activity of Morinda products has been attributed to the presence of terpenoids (mainly saponins) and phenolic compounds (acubin, alizarin, acopoletin, and anthraquinones) [31-34].

The mode of action of these substances on gut health is not clear but several mechanisms including i) modulation of microbial cell membrane and disruption of pathogenic microbes, ii) increased hydrophobicity which increases surface area of the microbial cell and reduces its virulence, iii) stimulation of beneficial bacteria (*Lactobacillus* and *Bifidobacteria*) in the gut, iv) stimulation of the immune system and v) improvement in intestinal integrity by protecting it against microbial attack have been postulated [35, 36].

Saponins act mainly through their membranolytic properties on microbial cell and leakage of cellular materials [37, 38]. Flavonoids may exert their antimicrobial activity by complexing with extracellular and soluble proteins and bacterial cell walls [39] or by disrupting microbial membranes [40]. Flavonoids are also known to modulate the number of cells signaling the pathways of fat deposition [41-44]. Catechins, a group of flavonoids, improve poultry performance mainly, through their antioxidative [45] and anticoccidial [46] properties. The antimicrobial activity of alkaloids is attributed to their ability to intercalate with cellular DNA [47]. Anthraquinones inhibit bacterial cell wall synthesis and membrane function [48,49] and microbial enzyme activity [50,51]. Depending on the category, high intake of anthraquinones may

however, be toxic. Shalan *et al.* [52] reported hepatotoxicity and high mortality in mice consuming 2 mg noni fruit extract/ml and attributed this to the anthraquinones (alizarin and rubiadin) contents. However, [14] found no toxic effect of noni water extract on mice. This suggests the need for analyzing Morinda products for anthraquinone concentration before considering them for inclusion in poultry feed. Several essential amino acids, carbohydrates, vitamins, minerals and co-enzymes [28] which may directly or indirectly improve tissue growth through increased nutrient metabolism have also been identified in Morinda products [4, 53, 13].

Anantharaj [30] reported the efficacy of Morinda fruit extract in altering blood lipid profile by reducing LDL cholesterol and increasing HDL, LDL ratio. The hypolipidemic and cholesterolemic activities of Morinda have been attributed to flavonoids, alkaloids and glycosides (mainly citrifolin) present in the fruit/seed [54,55,56,30, 57], leaves and roots [56]. Morinda supplementation showed immunomodulatory effects by increasing total leucocytes and inducing greater oxidative burst intensity by the primary neutrophil concentration, which improved resistance of cattle to disease in a high-risk population [7]. Quercetins, a bioactive ingredient in Morinda [59] has heat stress mediating effects in poultry [60]. According to Hong *et al.* [14] the immune enhancing activity of noni fruit extract is due to its modulatory effect on immune cells, induction of the expression of proinflammatory cytokine genes and inhibition of the expression of interleukin (IL10). The concentration of phytoconstituents in Morinda depends on several factors including the plant part and stage of maturity [61,62]. The composition of Morinda plant parts in selected phytochemicals is summarised in Table 1.

Morinda products in poultry feeding

The high concentration of compounds with several functional properties in Morinda products could make the phytoadditives of choice in livestock and poultry feeds. Morinda products (fruits, roots, bark and leaves) have gained popularity in animal nutrition in recent years [63-65]. There are few reports on the use of Morinda as phytoadditive in poultry feed, mainly broiler chickens and Japanese quails.

In a study with heat stressed broilers, [60] found no effects of 2 g/kg dried Morinda fruit powder on feed intake and growth, but the supplementation improved the hepatic expression of heat shock protein in a time-specific manner, suggesting

TABLE 1. Selected phytochemicals and their distribution in *M. citrifolia* plant parts

Constituents	Plant part	Sources
Anthraquinones		
<ul style="list-style-type: none"> • Deacetylasperulosidic acid • 1,2-Dimethoxyanthraquinone • Damnacanthol-3-O-β-D-primeveroside • Morindone -6-O-β-D-primeveroside 	Root	[73, 74, 75]
Flavonoids		
<ul style="list-style-type: none"> • Catechins • Epicatechins • Kaempferol • Anthocyanin • Quercetin 	Fruit and leaf	[59, 42, 44, 76, 77, 78]
Terpenes		
<ul style="list-style-type: none"> • Saponins • Ursolic acid 	Fruit and leaf	[79, 80, 81, 82, 83]
Polyphenols		
<ul style="list-style-type: none"> • Chlorogenic acid • Gentisic acid • P-hydroxybenzoic acid 	Fruit	[27, 26, 41]
Glycosides		
<ul style="list-style-type: none"> • β-D-glucopyranoside • Citrofolinin- A • Citrofolinin- B 	Leaf	[73, 84]
Sterols		
<ul style="list-style-type: none"> • β-sitosterol 	leaf	[19]
Lignans		
<ul style="list-style-type: none"> • Isoprincepin • Americanin A • Americanin B • Morindolin • 3,3'-Bisdemethylpinoresinol 	Fruit	[85, 25, 86, 87]
Coumarins		
<ul style="list-style-type: none"> • Scopoletin 	Fruit	[86, 88, 89, 90, 91, 92]
Acids		
<ul style="list-style-type: none"> • Caprylic acid • Caproic acid • Hexanoic acid • Linolenic acid 	Fruit and seed	[9, 93, 19, 18]
Vitamins		
<ul style="list-style-type: none"> • Vitamin C • Vitamin E • Vitamin A 	Fruit	[94, 95, 23]

that Morinda powder may have potential role in relieving heat stress in poultry. In another study, Morinda fruit extract supplementation at 1.5 ml/bird/day improved weight gain, feed conversion ratio and dressing percentage in broilers compared to the control diet [66]. Sunder et al. [67] also observed improved growth and feed utilisation of

Japanese quails supplemented with 5 g Morinda fruit extract/kg feed. Inclusion of Morinda fruit powder at 150 g/kg diet improved body weight gains and feed conversion ratio in Japanese quails [68]. Sunder et al. [69] found that replacing a concentrate mixture with Morinda fruit granules at 200 g/kg (w/w) improved body weight gain

and egg production in Japanese quails. According to Sunder *et al.* [65], there is a synergistic effect between Morinda extract and lactobacillus in terms of body weight gain, feed efficiency, immunomodulation and reduction of gut *E. coli* count in poultry, confirming the antimicrobial activity of Morinda products.

Supplementation of diets with Morinda fruit or leaf extract at 5 g/kg diet lowered serum cholesterol in broiler chickens [70]. Santoso *et al.* [21] also reported increased HDL/LDL ratio and reduced plasma triglycerides in broilers

supplemented with 5 g Morinda fruit powder/kg diet. Addition of Morinda fruit powder at 3 g/kg diet reduced plasma cholesterol and triglycerides below 50% in broilers [70]. Beta-sitosterols identified in Morinda products [28] have cholesterol-lowering activity [72]. These findings suggest that factors including plant part, processing method and performance criteria targeted need to be considered in the evaluation of Morinda for poultry feeding. The response of poultry to dietary morinda products is summarised in Table 2.

TABLE 2. Response of poultry to dietary *M. citrifolia*

Morinda product	Inclusion level	Major findings	Sources
Fruit powder	2 g/kg diet	Improved hepatic expression of heat shock protein in broilers.	[60]
	150 g/kg diet	Improved body weight gain and feed conversion efficiency in Japanese quails.	[68]
	50 g/kg diet	Increased HDL/LDL ratio and reduced plasma triglycerides in broilers.	[21]
	30 g/kg diet	Reduced plasma cholesterol and triglycerides below 50% in broilers.	[71]
Fruit or leaf extract	50 g/kg diet	Improved weight gain, feed efficiency, immunomodulation and lowered plasma cholesterol and gut <i>E. Coli</i> count (broilers).	[70, 65]
	1.5 ml/bird/day	Improved body weight gain, feed efficiency and dressing percentage in broilers.	[66]
	50 g/kg diet	Improved body weight gain, feed efficiency in Japanese quails.	[67]
Fruit granules	200 g/kg concentrate mix	Improved feed efficiency and egg production in Japanese quails.	[96]

Prospects of morinda products in poultry feeding and future research

The exceptional adaptability of Morinda plant coupled with its rich nutritional and nutraceutical profile and low food demand make it a potential alternative to chemical additive in poultry diets. These properties coupled with the growing concern in the use of chemical substances in poultry feed will increase the adoption of Morinda products in the feed. However, the wide variability in the composition, due to factors including stage of growth, growing conditions and plant parts, calls for more research in the application of Morinda products as additives in poultry feed. The feeding of Morinda products to poultry of different species

and age will also increase our understanding of possible animal factors affecting their utilisation by poultry. The effect of diet composition on the utilisation of Morinda products by poultry also need to be studied as this may positively impact cost of poultry production. Detailed studies of the threshold of the different chemical compounds in Morinda products also need attention in order to minimize the risk of toxicity on the consuming bird.

Conclusions

The nutritional and nutraceutical compositions of *Morinda citrifolia* make it a potential phytoadditive in poultry feed. Several products

from the fruit (extract, powder, granule) and leaves (powder and extract) have potential as antimicrobial, digestion enhancing, cholesterol reducing, immune modulation and heat stress reducing effects among others in poultry. *Morinda* products can be included in the diet in place of chemical additives to produce cheaper and consumer friendly poultry products. Currently however, reports on their use in the feed is mainly limited to broiler chickens and Japanese quails. There is need for more research into plant and animal factors and processing methods for maximum utilisation of *Morinda* products in poultry diets. More research is also recommended into the application of *Morinda* products in other poultry species.

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Conflict of interest statement

The research did not involve any commercial or financial relationships that may be construed as potential conflict of interest.

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