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REVIEW - PROSPECTS OF UTILIZATION OF MANGO SEED KERNEL IN AQUA-FEED

M.M.Ghughuskar

Ph.D.Scholar,

Aquaculture Division

ICAR-Central Institute of Fisheries Education,Versova,Andheri(W),Mumbai

Abstract

India is one of the highest Mango producing countries in the world which accounts for 62% of the total world production of Mango. It is estimated that mango consists of edible pulp 33-85%, kernel-9-40%, and inedible peel-7-24%. Due to this during industrial Mango processing, a large quantity of waste is generated which has serious disposable problems. One of the solutions is to use this waste as feed for animals due to this there will be less completion for the ingredients which are used for human consumption. But the Mango seed kernel which is a waste from processing can be used as a feed ingredient in fish feed. But the problem is using this product in feed is that it contains anti-nutrients and toxic components such as saponins, lectins, tannins, trypsin inhibitors, and cyanogenic glycosides which make them unsafe as protein and carbohydrate sources in livestock production. Many simple processes are been reported for reduction or removal of ant nutritional factor and toxic components are boiling, drying, soaking, leaching and fermentation. If mango seed kernel waste is managed properly it will be an additional asset to the mango processor, fish farmers and fish feed mill owners, etc. without compromising the environment.

Keywords: *Anti-nutrients, Fish feed, Mango seed-kernel meal, Fish*

Introduction

India's fisheries sector is booming economic activities which provide both employment and need protein to the people. After Independence fisheries together with agriculture recognized it as an important economic sector. Its vibrancy can be recognized by the fact that in 1950 its production was to tune of 0.75 million tonnes and present 2012-13 production touches to 9.6 million tonnes which estimated to be 11 fold increments. This sector annual growth rate of over 4.5 per cent due to this India on the forefront of global fish production, only after China. The fisheries sector not only fulfil the domestic demand of India but also provide employment opportunities and much needed foreign exchange which is was the tune of US$ 3.51 billion (2012–13) from fish and fisheries justify the importance of the fisheries sector on the economy and livelihood security. In developing countries, fish production increase and the problem faced by these countries is the lack of a nutritionally balanced diet and low-cost feed.(Falaye,1992;Avnimelech etal.,2008). In fish culture, feed cost accounts for 60-70% of the production cost due to the high cost of feed ingredients. Feed ingredients used in fish feed is also a staple food for human in many developing countries. Due to this escalating and scarcity of conventional animal feed ingredient it necessary to evaluate alternative nutrient resource in aquaculture feed. Many researchers substituted the conventional feed ingredients with inexpensive agro-industrial products like water fern (*Lemna paucicostata*) (Fasakin *et al*,2001) duckweed (*Azola africana*) (Mbagwu *etal*.,1990,Youssout *etal.*,2007), coffee pulp(Ulloa Rojas and Verreth,2003) and house fly maggot (Ugwumba *etal*.,2001)

Mango (*Mangifera indica*) is a delicious tropical fruit relish throughout the world. Mango belongs to the genus *Mangifera* consisting of numerous species of tropical fruiting trees in the flowering plant family *Anacardiaceae*. The mango is indigenous to the Indian subcontinent and South Asia.(Fowomola,2010). It is the most extensively exploited fruits for food, juice, flavour , fragrances and colour and common ingredients in new functional food often called Superfruit. El Saadany et al., 1980; Jansman et al., 1995; Teguia, 1995; Anand and Maini, 1997; Diarra and Usman, 2008; Diarra et al., 2010; 2011 revealed that it is a good source of carbohydrates (NFE) while Anand and Maini, 1997 reported that it contains high quantities of proteins and fats.

Mango kernel is the cheapest and readily available agro-processing by-product which is presently utilized but can be used to enhance nonspecific immunity in fish (Sahu *et al*., 2007). Mango seed kernel has good attributes as the cheapest non-traditional feed ingredient but it contains many anti-nutritional factors (e.g. tannins, phytate, cyanide, antitrypsin, oxalate and saponins) which limit its utilisation. Drying, soaking, leaching and fermentation have been reported to be simple means of detoxifying these feed sources to reduce the presence of anti-nutrients and toxic components (Aregheore 1998). Several methods are used for reducing anti-nutritional factors like boiling used to reduce the tannin content of mango kernel (Diarra and Usman 2008). Boiling reduced the tannin content by 87.26% reduction (Diarra et al. 2011). No adverse effect of anti-nutritional factor reducing process i.e. boiling on crude protein, crude fibre, ether extract and nitrogen free extract of the kernel. (Diarra, et al. 2010) . Tannin is one of the most responsible anti nutritional factors. Amongst these factors, tannins are largely responsible for the poor nutritional value of MSK. Several processing methods have been used to reduce the concentration of anti-nutritional factors in MSK and improve its utilisation by the animal husbandry feed industry. This paper reviews the composition (nutrients and ant nutrients) of Mango Seed Kernel and its use in aquaculture. and processing methods to enhance its utilisation.

Nutritive content of Mango Seed Kernel

Mango constitutes high in probiotics, fibre, vitamin C, polyphenols, carotenoids and minerals (FAO,2004). Mango kernel constitutes 13 % of the weight of the fruit. Waste generated from mango is about 40 to 60% after consumption and industrial processing. It was estimated that peel constitutes 12 to 15% while the kernel is about 15 to 20%. (Budhawar, 2002).

Lakshminarayana *et al.* (1983) analysed the mango seed kernel of 43 varieties and found that there was a wide difference in protein (4.0-8.1%), fat (3.7-12.6%) and ash (1.0-3.7%) on a dry matter basis. The starch content of two mango varieties (Chausa and Kuppi) in South Korea was 75.6 and 80.0% respectively. Mango seed kernel(MSK) is a good source of starch which is in the range of 58-80% (El Saadany, 1980) and has a high-fat content (Diarra *et al.,* 2011). It has metabolisable energy (ME) value that is comparable to maize (Diarra et al., 2011).MSK has 6-13% protein with a good essential amino acid profile especially Lysine and Methionine which is comparable to Maize (Kiflewahid *et al*., 1982; Dhingra and Kapoor, 1985; Ravindran and Rajaguru, 1985; Arogba, 1999; Odunsi, 2005; Ekpe et al., 2007; Fowomola, 2010; Diarra et al., 2011)

Table 1 Essential amino acid profile of different ingradients (g/100 g DM).

Essential Amino acids	**Ingredients (g/100g Dry Matter)**		
	Mango Seed Kernel(MSK)	**Maize**	**Soybean meal**
Lysine	3.13- 5.0	0.26	2.22
Methionine	1.04- 2.2	0.17	0.53
Threonine 2	2.04- 4	0.29	1.41
Arginine	5.17- 9.0	0.37	2.60
Valine	3.80- 5.2	0.39	1.68
Histidine	2.31- 2.7	0.23	0.96
Phenylalanine	4.46- 4.60	0.39	1.83

Isoleucine	3.23- 4.60	0.28	1.61
Reference	Fowomola, 2010; Jadhav and Siddiqui, 2010; Ashoush and Gadallah, 2011; Kittiphoom, 2012; WHO, 1985	NRC ,1998	NRC ,1998

Schieber et al., 2001; Gunstone, 2006; Jadhav and Siddiqui, 2010; Medina et al., 2010; Diarra et al., 2011 reveal that MSK meal has 6-16% oil which is good source of Stearic (24-57%) and oleic acid (34-56%).

Anti-nutritional factors (ANFs) in Mango Seed Kernel (MSK)

Use of Mango Seed Kernel (MSK) is limited despite high nutritive content due to the presence of many Anti-nutritional factors (ANFs). Major ANFs identified in (MSK) are tannins and cyanogenic glucosides (Teguia, 1995; Ravindran and Sivakanesan, 1996; El Boushy and Van Der Poel., 2000; Farag, 2001; Sanon and Kanwe, 2010; Ashoush and Gadallah, 2011; Dakare *et al.*, 2012). Oxalates (Ravindran and Sivakanesan, 1996; Dakare *et al.*, 2012) and phytates, saponins, alkaloids and flavonoids (Dakare *et al.*, 2012) have been reported in trace quantities.

Mango kernels are fairly rich in tannins, which progressively lead to reduced growth rates and less efficient feed utilization when included as a major component in diets for pigs and poultry (Moore 2004). They also contain cyanogenic glucosides, (64 mg/kg DM), oxalates (42 mg/kg DM) and trypsin inhibitory (20 TIU/g DM) (Ravindran *et al.* 1996). These anti-nutrients chelate divalent ions like Ca2+, Mg2+, Fe2+, and Zn2+ and also react with the charged groups of protein and polysaccharides thereby forming indigestible complexes while the toxic substances interfere with nutrient bioavailability and utilization (Haslam 1989; Reed 1995; Giner-Chavez 1996; Osagie 1998).

Table 3 Summarised Anti-nutritional factors Concentration in Mango Seed Kernel (MSK) meal

Anti-nutritional factors in Mango Seed Kernel (MSK) meal	Anti-nutritional factors Concentration	References
Condensed tannins (g/kg DM)	1.2 - 4.0	Ashoushand Gadallah (2011); Teguia (1995); Sanon and Kanwe (2010); Dakare et al. (2012)

Tannic acid(g/kg DM)	56.5 - 75	Ashoushand Gadallah (2011); Teguia (1995); Sanon and Kanwe (2010); Farag (2001);Dakare et al. (2012)
Hydrocyanic acid (g/kg DM)	64 - 71	Farag (2001); Ravindran and Sivakanesan (1996)
Oxalates (mg/kg DM)	11.92 - 42	Dakare et al. (2012); Ravindran and Sivakanesan (1996)
Trypsin inhibitor activity (TIU/g)	20 - 30	Farag (2001); Dakare et al. (2012); Ravindran and Sivakanesan (1996); Fowomola (2010)
Phytates (mg/100g)	1.44 - 487.3	Dakare et al. (2012); Fowomola (2010)
Alkaloids (mg/100g)	1 - 6.3	Dakare et al. (2012); Fowomola (2010)
Saponin (mg/100g)	4 - 10.5	Dakare et al. (2012); Fowomola (2010)

Effects of processing on the ANF content of MSK

Researchers like Teguia, 1995; Ravindran and Sivakanesan, 1996; Diarra et al., 2011 investigated the effect of different processing methods for reduction of Antinutritional Factors in Mango Seed Kernel. They revealed that soaking and boiling methods significantly lower the Antinutritional Factors of Mango Seed Kernel. Ravindran and Sivakanesan, 1996; Diarra et al., 2011also revealed that soaking or boiling methods also have an added advantage that it increases the Metabolic Energy of Mango Seed Kernel i.e. dried raw mango kernel ME was 7.9MJ/Kg DM when undergoes processing like soaked and boiled increases the ME to 10.3 MJ/kg DM. Ravindran and Sivakanesan, 1996; Diarra et al., 2011; Dakare et al., 2012 investigated that there is an increase in nitrogen-free extract (soluble carbohydrates) in processed Kernel due to the breakdown of complex carbohydrate fractions. It was reported that MSK when dry heat-treated results in an increase in ME as compared to raw MSK. (Amao and Siyanbola ,2013)

The effects of different processing methods on the reduction of ANFs in MSK have been investigated. Soaking and boiling were reported to significantly lower the ANF contents of MSK (Teguia, 1995; Ravindran and Sivakanesan, 1996; Diarra et al., 2011). MSK when undergoes treatments like Soaking, boiling, autoclaving, acid or alkali treatment removes tannins and trypsin inhibitors (El Boushy and Van Der Poel., 2000; Farag, 2001; Dakare et al., 2012) and the

HCN (El Boushy and Van Der Poel, 2000; Dakare et al., 2012) in MSK. The boiling method is a more efficient method for removing antinutritional factors like tannins and HCN as compared to soaking. Ravindran and Sivakanesan (1996). Patil et al., 1982 revealed that msk treated with acid followed by alkali removes all of the tannins and much of the cyanogenic glucosides of MSK. Anti-nutritional factors like tannin, HCN, trypsin inhibitor activity and oxalate are reduced in boiling treatment as compare to soaking MSKwhile boiling the MSK in alkali was the most efficient method for reducing the phytic acid content. (Dakare et al. ,2012). Phytate and oxalate are effectively reduced by boiling in the water while HCN is efficiently reduced by using the method of soaking. Combination of two process soaking and autoclaving of MSK result in maximum reduction of tannin and enhancement of MSK protein. (Messay and Shimelis, 2012).

Table: Effect of selected processing methods on the anti-nutritional factor reduction in Mango Seed Kernel.(MSK)

Reduction of Anti-nutritional factors in Mango Seed Kernel (MSK) meal	**Soaking in water**		**Boiling in water (100°C for 30min)**	**Soaking 24 hrs + boiling (30min)**	**References**
	24 hrs	**72 hrs**			
Tannins	48.2	-	61.1	80.2	Dakare et al. (2012);
	-	42.86	47.43	-	Abdullahi (2012)
	-	-	65.51	-	Diarra et al. (2010)
	61.0	-	-	-	EL Boushy et al. (2000)
	-	-	84.0	-	Abdulrashid et al. (2007)
Cyanide	-	-	84.0	-	EL Boushy et al. (2000)
		77.78	77.78	-	Abdullahi (2012)
	19.1	-	37.6	57.1	Dakare et al. (2012)
Trypsin inhibitor activity	33.8	-	98.2	100	Dakare et al. (2012)

Phytates	-	82.22	84.44	-	Abdullahi (2012)
	23.8	-	42.8	52.5	Dakare et al. (2012)
Oxalates	=	20.0	24.0	-	Abdullahi (2012)
	22.6	-	81.1	89.7	Dakare et al. (2012)

Feeding trials in aquatic organism

Some workers like Omoregie (1991), Omoregie (2001) and Belsare and Singh, 2007 used Mango seed Kernel in the diet of juvenile *Oreochromis niloticus* and *Labeo senegalensis* and Postlarvae of *Macrobrachium rosenbergii* respectively.

Many researchers study the effect of varying levels of mango seed kernel incorporated diet of different fishes and prawns are summarized below.

Name of the Fish	Dose of the Mango Seed Kernel	Size of Fish And stocking rate	Optimum Dose	Benefits	Reference
L.rohita	0 (Control), 1g, 5 g, 10 g mango kernel $kg^{(-1)}$) dry diet Duration-60 days.	Fingerlings W-10±2g @30nos./ 500ml	5g/Kg	Highest percentage survival Stimulates the immunity and makes *L. rohita more* resistant to *A. hydrophila* infection. Enhanced superoxide anion production, lysozyme, serum bactericidal, serum protein, albumin, A:G ratio	Sahu *etal.*,2007

Nile Tilapia (*Oreochromis niloticus*)	0%,25%,50%, 75% and 100% Fermented Mango Seed Kernel Duration-84days.	Fingerlings W-4.76±0.32g @150nos./ 250ml	50% Fermented Mango Seed Kernel	Reduce the price of feed .50% inclusion level in the diet of Nile Tilapia as carbohydrate source.	Obasa *etal.*,2013
Nile Tilapia (*Oreochromis niloticus*)	Mango Seed Kernel - 80g,55g,25g Cassava peel- 80g,55g and 25g	Fingerlings W-5±0.9g @10nos./ Tank	Mango Seed Kernel -55g/+ Cassava peel 25g/100g feed- Good FCR	Highest FCR	Omoregie,etal.,1991 2001
Labeo senengalensis	0%,10%,20% and 30% Duration-12 weeks	Juvenile W-3.53±0.02g @20fish/ 20L	10%	Mango Seed Kernel can be incorporate in the diet of Juvenile without significant depression in growth and no nutritional pathology	Omoregie, 2001
Macrobrachium rosenbergii	Mango Kernel Seed (10%),Banana Peel(10%)and Papaya peel(10%) Duration-90	Post Larvae L-1.2 -1.4cm W-0.09-0.13g @30PL/ 40L	10% Mango Kernel Seed	Increases survival rate,weight gain/biomass index,Specific growth rate Increase total protein,carbohydrate,	Aammugam *etal.*,2013

	Days			Lipid and Ash	
Macrobrachium rosenbergii	Mango Kernel Seed 5, 10, 15, 20, 25 and 30%. Duration-42 Days	Post-larvae L- 1.80±0.027 cm, W- 0.042±0.002 g @30PL/ 15L	5% Mango Kernel Seed	Significantly improve the growth rate and survival of post larvae	Belsare and Singh,2007

Conclusion:

After reviewing different research work of Scientist indicates that Mango Seed Kernel can be incorporated into the feed of aquaculture candidate species to some extent and helps to reduce the cost of feed. A lot of efforts has to be taken into consideration while incorporating Mango Seed Kernel as it has good protein value which is parallel to conventional feed ingredients but it has high antinutritional factors which are toxic to the aquaculture candidate species.

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