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A review on: Impact of processing on nutritional and antinutritional factors of moth bean

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Abstract
Moth bean (*Vigna aconitifolia*) is a legume crop grown primarily in India and other parts of Asia. While it is a good source of protein, fiber, and other nutrients, it also contains anti-nutritional factors (ANFs) that can inhibit nutrient absorption and cause health problems in humans and animals. Processing techniques such as soaking, boiling, gemmation, fermentation, and roasting have been shown to reduce or eliminate these ANFs, making moth bean a more nutritionally valuable food. This review article summarizes the current state of knowledge regarding the effects of processing on the ANFS in moth bean, including phytic acid, tannins, protease inhibitors, and lectins. It also discusses the potential health benefits of consuming processed moth beau, as well as future research directions in this field Further studies should be conducted to investigate the effects of processing on the bioavailability of nutrients in moth bean such as iron, zinc, and calcium. This will help determine the most effective processing methods for maximizing the nutritional value of the crop. Also to determine the optimal processing conditions for each processing method in order to achieve maximum reduction in NFS while preserving the sensory and nutritional qualities of the crop. Long-term studies are needed to evaluate the health outcomes of consuming processed moth bean in different populations, particularly those at risk of micro nutrient deficiencies or chronic diseases. Also needs to explore the potential of using moth bean as a functional food ingredient, given its unique nutritional profile and Finally, research should be conducted to develop sustainable and efficient processing methods that can be adopted by small-scale farmers in developing countries where moth bean is a essential crop, to ensure its safe consumption and potential health benefits, contribute to food security.

Keywords: Moth bean, nutritional, anti-nutritional factors (ANFs)

1. Introduction
Legumes are a wide variety of crops that are enclosed in flowering plants producing seeds in pods and frequently raised for food and feeds. They were ranked as the third-largest family of flowering plants with species over 19500 and genera of range higher than 750. (Abbas & Ahmad, 2018) [1].

They are important constituent for the human diet, it increase the nutritional status of the cereal-based diets.They are the Efficient source of energy, carbohydrates, proteins and fiber also the good source of B-group vitamins they are rich source of bioactive compounds i.e phenolic and flavonoid content which have a very beneficial impacts on the human health. In India the wide varieties of legumes are cultivated cowpea, chickpea, lentil, moth bean, green gram etc., are the example of legumes. Among the leguminous crops the moth bean (*Vigna Aconitifolia*) is desiccate in western Rajasthan, they are the utmost significance due to its drought and heat intolerance characteristics present in it (Kumar *et al*., 2017) [4]. Depending upon the region they famous as there different names such as dew bean, Indian moth bean, mat bean, haricot mat, moth gram, Turkish gram or matki, etc (Bhadkaria *et al*., 2022) [2].

Moth bean are appreciated due to it's high quality of protein content is present and carbohydrates associated with an adequate amount of minerals like (Fe, Zn, Ca, Mg, and Mn), vitamins like (ascorbic acid and niacin), essential amino acids like glutamic and aspartic acid, Leucine and lysine is present in abundantand amount and linoleic acid is the most common fatty acid present in it (Kumar *et al*., 2019) [27]. One of the main limiting drawback is the nutritional and food qualities will be the presence of anti-nutritional factors although, Some of the conventional processing methods like: Soaking, roasting, sprouting, and cooking can be done before consumption can eliminate the anti-nutritional factors of moth bean seeds. (Medhe *et al*., 2019) [31].

Sprouting can be the effective process to eliminate anti-nutrient factor and it can catalyse secondary metabolites like α-galactosides and phytates and the anti-nutrients factor like trypsin inhibitors and flatulence-causing oligosaccharide levels can be decreased or inactivated during the cooking process (Hamid *et al*., 2016) [3], however sprouting considered as the best powerful method for maximizing their antioxidant activity. The bean flours are utilized as additives for some of the food products such as breads, biscuits, pasta, cakes as they supply value to the product. They are most commonly consumed as in cooked and seasoned (with spices) beans (whole as well as dhal) or in sprouted form and cooked form (usually stir-fried with suited spices) beans, superior to consumption. Alternatively, the beans or dhal prepared from the unsprouted seeds may get deep-fat fried (dal muthia) and mixed with other savoury snacks (Salve & Mehrajfatema, 2011) [39].

It indicated that the processing of moth bean can led to a change in their functional and physiochemical properties which can changes fractions of beans.

2. Production

In India, moth bean is one of the most drought resistant pulses growing of moth bean is easy. Rajasthan, state of India contributes almost 85% of crop production. Moth bean is primarily impacted by Mung bean yellow mosaic virus. Low yield of Cultivating resistant plant cultivars can be overcome by the additional yield advantage is that appropriate seed treatment of rhizobium culture can give additional yield advantage. In addition, the the selection of right cultivar variety types is key factor for production for enhancement is for available soil types, when its compared to other commercial crops like chickpea and cowpea moth bean is the crop needs less care (Marathe *et al*., 2011) [30]. Advanced agricultural practices will address the challenges of food security and climate change and also promote the production.In India the productivity of moth bean seems productive and is estimated more than 1.5 million hectares with an annual production of 0.4 million tons (Senthilkumar & Ngadi, 2020) [41]. It can be cultivated in arid and semiarid regions as being a drought-resistant crop, arid regions of Rajasthan in India. About 85% of total moth bean cultivation and 0.22 million tons of moth beans produced in Rajasthan (Bhadkaria *et al*., 2022) [2]. Average seeds yield is being grown under dry land conditions without supplementary irrigation and low fertility estimated in a range of 70–270 kg ha^{-1} which is low but probably due Though it yields up to 2600 kg ha^{-1} as recorded in the United States and Australia with experimental seeds (Oweis & Hachum, 2006) [35]. This recommends that it needs to improve breeding efforts towards hot climate adaptive crops with resistivity to abiotic and biotic stresses (Harouna *et al*., 2018) [20].

3. Processing of moth bean

3.1 Soaking

During soaking into water for 12 h with mineral salt at room temprature resultant in reduction of the amount of phytic acid 46–50% at maximum level. Furthermore, *in vitro* carbohydrate and protein digestibility will be enhanced by 19–36% and 1–8%, respectively (Negi *et al*., 2001) [34] Equally,the tannin level of moth bean will be dramatically lowered as well as the total sugar content of seeds (Yadav *et al* 2023) [50].

3.2 Germination

In the Germination process it has been reported that the bioavailability of protein incresed by 30% (Sedani *et al*., 2021) [40], also the polyphenol and phytic acid content have been reducing effectively in the grains, amylases catalyze the hydrolysis of starch, stored as amylose and amylopectin, to simple sugars, i.e., the reducing sugars maltose and glucose, to a lesser extent, the non-reducing sugar sucrose resultant in a higher digestibility. (Bhadkaria *et al*., 2022) [2] In the whole seed of germinated sprouts boost riboflavin, niacin and thiamine content the seeds has reported to enhance the protein and starch digestibility, as well as the antioxidant activity and phenolic content. (Ba & Vs, 1965) [16].

3.3 Fermentation

Fermentation enhances the acidity, pH, probiotic count, antioxidant and polyphenol levels. At various temperatures and time periods results in significant improvement in protein and starch digestibility by reducing the quantity of antinutrients in the moth bean seeds (Chavan *et al*., 2018) [48]. Also by creating fermented probiotic drinks with sugar, cardamom, and *L. acidophilus* using germinated as will as ungerminated moth bean seeds.

3.4 Cooking

The content of total soluble sugar, protein digestibility, total soluble sugar and the levels of starch improve while cooking. further more it lowers the carbohydrate content due to hydrolysis of total sugar. (Negi *et al*., 2001) [34].

Antinutrients such as phytic acid, tannins and total free phenols get reduced in the seeds. (Vijayakumari *et al*., 1998) [49].

3.5 Roasting

It boosts iron bioavailability while lowering phytic acid in moth bean seeds. There occurs no reducing in amino acids content due to roasting. It also enhances the rate of growth with the protein efficiency ratio of digestibility (Sathe *et al* 2007) [51].

3.6 Radiation

Gamma radiation increases the crude protein content, linoleic acid, polyphenols, eicosenoic acid and palmitoleic acid in moth bean seeds. It is equally important to eliminate antinutritional factors by improving self-life of the food material. Crude fat, crude fibre and antinutrients such as oligosaccharides, L-DOPA, trypsin inhibitors, hydrogen cyanide and phyto-haemagglutinins have all been reduced, (Gupta *et al*., 2016) [47].

4. Chemical composition

Pulses are recommended in diets because it provide nutritional support. Food legumes contain certain bio active compounds that execute nourishing properties when consumed in the daily diet. Different studies shows different methodologies with diverse range of sensitivity. A range of results is found, for some analyses, which may be related to environment, genotype or both. The approximate composition of moth bean seeds include ash, moisture, lipids, carbohydrates, proteins and fats. Reported studies advocate that moth bean seeds are higher in carbohydrates, proteins, minerals and fats but lower in fiber than chickpea, common bean and soybean. (Table 1) (Harouna *et al*., 2018) [20].

Table 1: Different studies shows different methodologies with diverse range of sensitivity

Nutrient	Raw Moth bean	Soaking	Germination	Cooking	Autoclaving
carbohydrate(g/100g)	60.23-63.17	58.46-58.76	56.05-69.93	75.01	55.8
Protein	21.3-23.6	21.09-22.09	16.71-23.82-25.33	12.70	34.88 l
Fat(g/100g)	1.13-1.48	1.13-4.08	1.09-3.68	6.21	0.90
Crude fiber(g/100g)	4.5-6.00		7.00	6.70-6.78	3.00
Moisture (%)	3.38-8.4	9.12-10.02	10.6-11.16	-	-
Ash (g)	3.4-3.47	2.67-3.2	2.40-3.27	2.00-2.73	4.17
Starch	26.32	52.17	59.49	-	-
Crude lipid	0.38	-	0.60	0.35	-
Micronutrients Vitamins					
Vitamin C (mg/100g)	3.7	7.4-9.88	9.66-12.3	-	-
Polyphenols (%)	1.30 -3.08	0.65-1.1	326.88-702	689	-
Phytic acid (%)	0.65-885.56	252.56-787.35	284.28-541	592	5.76
		741		-	
Saponins	2572-2 848	2706	1803-2734	1472-2 620	2242
Trypsin inhibitor activity (mg/100g)	20.24	14.70	5.86	-	-
Minerals					
Manganese(mg/100g)	1.3	1.5	2.1	2.4	2.3
Calcium(mg/100g)	97	87-1.83	221.0	-	199.0
Magnesium(mg/100g)	95-280.0	102-210.2	251.0	-	288.0
zinc	2.8	3.1	11.0	-	-
Phosphorous(mg/100g)	649.0	508.0	475.0	469.0	547.0
Iron(mg/100g)	9.8-12.5	9.8-11.0	9.8-11.3	6.86	5.6-11.5
Tannin (µg/100 g)	1.86-1.91	110-143.22	350		
References	(Medhe *et al*., 2019) [31] (Ba & Vs, 2020) [16] (Negi, Anju;Boora, P.;Khetarpaul, N, 2014) [35] (Jood *et al*., 1986) [22] (Khalil, 2001) [26] (Negi *et al*., 2001) [34]	(Ba & Vs, 2020) [16] (Negi, Anju;Boora, P.;Khetarpaul, N, 2014) [35] (Kataria *et al*., 1989) [21] (Khalil, 2001) [26] (Negi *et al*., 2001) [34]	(Medhe *et al*., 2019) [31] (Ba & Vs, 2020) [16] (Negi, Anju;Boora, P.;Khetarpaul, N, 2014) [35] (Jood *et al*., 1986) [22] (Khalil, 2001) [26] (Negi *et al*., 2001) [34]	(Medhe *et al*., 2019) [31] (Kataria *et al*., 1989) [21] S. S., & Jaipuri (2012) [11] Huma *et al*., 2008) [8]	(Duhan *et al*., 1989) [13] (Jood *et al*., 1986) [22] (Khalil, 2001) [26]

5. Nutritional processing of moth bean seeds

Through traditional processing methods the nutritional quality of any edible legume can be improved to reduce antinutrients. Dehulling, soaking, fermentation, germination, and enzyme treatment are some of the main processing procedures employed to decrease anti-nutritive components and thus boosting organoleptic quality. Dehusked splits of moth bean seeds are processed and used in human diets (Fig. 1). (Reid, 1971) [38].

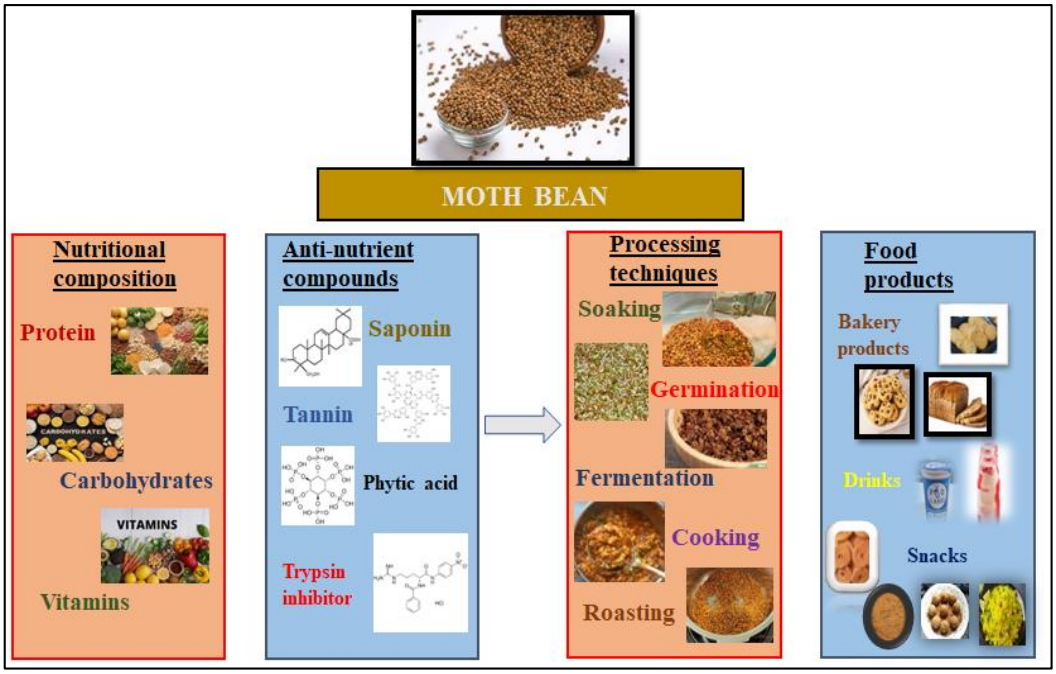

Fig 1: Processing of moth bean seeds for human consumption by soaking, sprouting, roasting, dehusked and grinded into four to prepare different products

6. Product development from moth bean

In developing countries, moth bean is a desirable for poor man's diet. Humans consume its seeds and young pods of the moth bean, while animals consume its leaves and stalks. Moth bean is used to make a variety of nutrient-rich products as shown in Fig. 1. Whole seeds, dehusked seeds, and germinated are the most common forms of consumption. Because of their richness in vitamin and mineral, moth bean seed sprouts are eaten as a vegetable/curry. Moth bean four is used to make traditional Indian cuisines such as papad, roti, bhujia, vada, mangori, kheech, rabri, and sandge (Adsule, 1996) [7]. In the rural population, the addition of whole seeds to a thick soup of whole seed meal aids in the reduction of the efects of cough and bronchitis (Kadam *et al*., 1985) [23].

Moth bean starch reported as a natural source of starch that may be used in a variety of food applications. The shelf life of fresh lemon was extended up to 12 days using modifed moth bean starch flms with potential functional features (Kumar *et al*., 2019) [27] The hydrophobic inert matrix of acetylated moth bean starch is supply in the formulation of controlled release tablets of lamivudine, which is prescribed in the treatment of hepatitis B (HBV) and acquired immunodefciency syndrome (AIDS) (Singh & Nath, 2011) [43]. Moth bean seed sprouts are widely consumed as raw and in vegetable rich in vitamin and mineral. When sprouted protein bioavailability is increased by 30% (Sedani *et al*., 2021) [40] and by scavenging free radicals helps to improves health. Sprouting alter physiochemical and functional food properties, which is important in the development of gluten-free food products thus attracting large market possibility. The moth bean four has the potency to be used in the development of gluten-free products, which have a considerable commercial prospective (Medhe *et al*., 2019) [31]. At various concentrations the functional qualities of composite fours were improved by adding moth bean seed powder to wheat four. In addition, bread samples enriched with moth bean seed powder had higher levels of essential amino acids except for lysine, than the dietary recommended value by FAO/WHO/UNU.

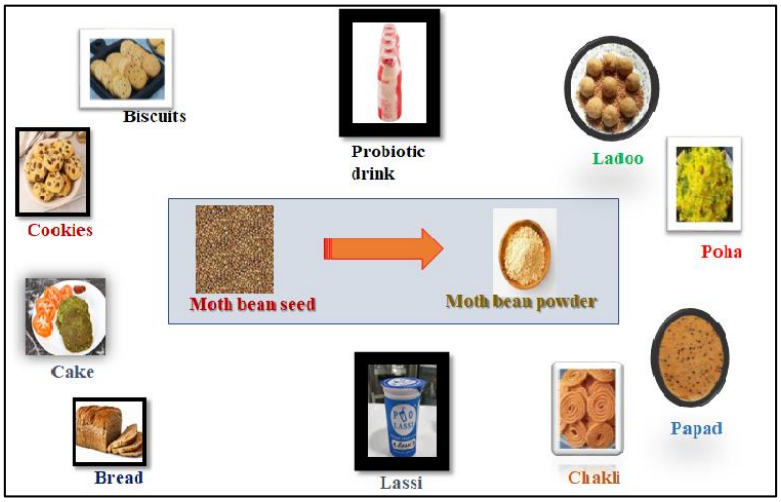

Fig 2: Product development from moth bean

7. Health benefts of moth bean

The therapeutic benefts of moth bean seeds are represented in Fig. 2. It is used to treat fever in rural areas, (Kumar *et al*., 2019) [27]. Its roots are narcotic in nature (Adsule, 1996) [7]. Cough and bronchitis can be treated with moth bean soup. In women it is also used to treat irregular menstruation cycles. It is also great for renal diseases due to the property as diuretic, astringent, and tonic (Adsule, 1996) [7]. By improving bile acid binding at active sites, moth bean protein efficiently causes hypocholesterolemia by reducing low density cholesterol and conspicuously boosting high density cholesterol levels (Kahlon *et al.*, 2005) [24]. Moth bean trypsin inhibitor has antiproliferative activity for lymphoma MBL2 cells (Ma *et al.*, 2010) [29]. The seeds of moth bean have anti-Parkinson activity (Ramya & Thaakur, 2007) [37]. Antioxidants and phytochemicals are bioactive molecules found in plants that can be used to cure or prevent variety of diseases (Suneeta Panicker, 2022) [36].

Moth bean seed extracts exhibit multiple antioxidant and inhibitory activities against α-glucosidase (IC50=50.42 mg/ mL) and pancreatic lipase (IC50= 7.32 to 9.85 mg mL−1) (Swanson, 2003) [45]. The presence of excess favonoids and phenolics in the ethanolic extract of moth bean confer antioxidant, anti-hypertensive, anti-diabetic properties. Moth bean sprouts contain ferulic, cafeic and cinnamic acids, as well as kaempferol, which help to decrease oxidative stress. The antibacterial activity of silver nanoparticles made from moth bean sprouts was tested against gram positive and gram negative microorganisms and reported to offers inhibition (Verma *et al*., 2021) [46]. Moth bean seeds are high in antioxidants, phenolic compounds, and enzyme inhibitors linked in the management of various chronic health conditions such as diabetes, anti-hypertensive effects and anti-infammatory. As a result, for human health consuming moth bean contains infuential nutraceuticals, that are beneficial thus, incorporating moth bean legumes protein into the development of functional meals with improved therapeutic potential would be a signifcant step towards improving health well-being (Bhadkaria *et al*., 2021) [12].

Natural phytochemicals and antioxidants are the bioactive compounds present in plants used to treat and prevent various diseases. Phytochemicals from these medicinal and functional food species represent a wide array of biochemicals for possible use in the medicinal industries (Benevides *et al*., 2018) [11].

8. Conclusion

Moth bean is being underutilized food legume constitutes potential nutraceutical properties having low glycemic index and rich in dietary fibre. Moth bean is potentially address the

food security concerns and provide a good source of plant-based proteins. It has the potentiality to aid malnutrition in *toto*. Celiac patients may get benefits in manufacturing gluten-free products by the usage of moth bean. It delivers a balanced nutrition when added to cereal based foods. Moth bean seeds can influence direct health benefits on its consumption by its Food-bioactives. In developing world the seeds of the legume are nutritive, draws the attention of plant breeders for quality cultivar production meeting dietary protein requirements for human consumption.

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