

Flowers of *Madhuca indica* J. F. Gmel.: Present status and future perspectives

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Madhuca indica J F Gmel. syn. *M. latifolia* Macb. commonly known as mahua is a large tree found in the dry deciduous forests of India. The tree produces edible flowers and fruits during leanest season of agriculture (March-May). Collection of mahua flowers and fruits is one of the most important sources of employment for the poorest of the poor in India. The flowers are edible and rich source of sugar, protein, vitamin and minerals. Present paper reviews the earlier research on these flowers and highlights the study conducted for value addition. About 80 per cent of juice was successfully extracted from fresh flowers and concentrated to produce a honey like liquid sweetener. The produced concentrate was analyzed and used for preparation of bakery and confectionary goods. Apart from this fresh flower pulp was used for preparation of jam, jelly and sauce. The study shows the income and employment generation potential of mahua flowers.

Keywords: Mahua flowers, *Madhuca indica*, Natural sweetener, Non timber forest products.

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Introduction

The greatest threat to the survival of humanity is the ever-increasing gap between population growth and food supply. FAO, in its annual report "The State of Food Insecurity in the World 2002", estimates that there were around 840 million undernourished people in 1998-2000, 799 million in the developing countries, 30 million in the countries in transition and 11 million in the industrialized countries^{1,2}. In order to arrest the situation, much attention has been given on the exploitation and utilization of unusual food plants. In such a situation it is important to develop suitable processing technologies for edible, non-timber forest products (NTFPs), which can be a potential source of nutrition.

NTFPs are the backbone to the Indian forest economy contributing over 50% to the forest revenues. According to a report, the export earnings from NTFPs are about US \$ 1,331 million³. Some of the major edible NTFPs of India are sal seeds, mahua flowers and fruits, myrobalans, bamboo shoots, mushroom, etc. Among these, mahua flowers are one of the most important NTFP, playing a major role in the tribal economy.

Large numbers of mahua trees are found in the states of Uttar Pradesh, Madhya Pradesh, Orissa,

Jharkhand, Chhattisgarh, Gujarat, Andhra Pradesh, Maharashtra, Bihar, West Bengal and Karnataka. The estimated production of mahua flowers is more than one million tonne in the country. In many states, government organisations like tribal development co-operative corporations (TDCC) purchase the flowers at a minimum support price to set aside the collectors from the exploitations of the middleman. However, due to lack of suitable post harvest processing technologies, most of the flowers get decomposed in the Government godowns. At present the only industrial utilization of these flowers is in production of liquor, which is illegal in most of the states.

To find out the potential of mahua flowers in food industry, we started working on value addition to fresh mahua flowers in 2004 under a DST sponsored project and successfully developed a number of food products like juice concentrate, jam, jelly, sauce and mango-mahua leather⁴. An Indian patent has been filed for developing an antioxidant liquid sweetener from fresh mahua⁵. Present paper reviews the present status (chemical composition, nutritional and medicinal properties and its utilization) and discusses the future perspectives (highlighting the studies done for value addition of these flowers).

Present status

Most of the studies conducted on mahua flowers are focused on preliminary chemical analysis of dried flowers and its uses in production of different fermented

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products (alcohol, lactic acid and acetone) and sugar syrup. An overview of these reports is given below.

Chemical composition

List of references for chemical analysis of dry flowers has been given in Table 1. A comparative nutritional analysis of mahua flower with common fruits was also done using the data published in the Handbook on Nutritive Value of Indian Foods (ICMR Publication)⁶ to explore the potential of mahua as a source of nutrition (Table 2). According to the findings

of literature survey, major constituents reported in mahua flower are sugars (reducing and non-reducing), polysaccharide, fibre, protein, amino acids, fat, minerals, vitamins, enzymes and organic acids.

Total sugar content of 40-70% (on dry weight basis) is reported by different scientist in samples collected from different geographical region⁷⁻¹⁰. Similarly, reducing sugar 48-57% and non-reducing sugar 3-18% has been reported⁸⁻¹¹. Paper chromatographic analysis of unhydrolyzed mahua extract shows the presence of maltose, sucrose, glucose, arabinose, fructose and rhamnose, whereas the hydrolyzed extract show the presence of galacturonic acid and absence of sucrose, others being the same⁸. Studies are also reported on the isolation and structure determination of mahua flower polysaccharide¹²⁻¹⁴. HPLC analysis of the concentrate prepared from the juice of fresh flowers shows the presence of sucrose, glucose and fructose in 1:2.1:2.3 ratio⁴. These results show the potential of mahua flowers to be used as a novel source of natural sweetener.

The nitrogen content of the flower varies from 0.65-1.1% being apparently higher in the younger than in the well developed flowers¹⁵. The protein content of the flowers^{6,9,10} varies from 4.4-7%. Presence of eleven different amino acidssuch as lysine, arginine, aspartic acid, glutamic acid, threonine, valine, tryptophan, phenylalanine, isoleucine, leucine and proline has also been reported^{8,10}. Table 3 gives a comparison of the essential amino acids of mahua flower protein with that

Table 1—Major constituents of dry mahua flowers

Composition	References
Total sugar	7, 8, 9, 10,
Reducing and non-reducing sugars	8, 11
Maltose, Galactose, Arabinose, Glucose, Fructose, Xylose, Galacturonic acid	8
Polysaccharide	12, 13, 14
Crude fibre	9
Nitrogen/Protein content	6, 9, 10, 15
Amino acids	8, 10
Fat	6, 8, 9, 10, 17
Minerals (Ca, Fe, Mg, P, K & Na)	8, 9, 10, 18, 19
Vitamins (Thiamin, Riboflavin, Ascorbic acid, Folic acid and Niacin)	6, 9, 10, 18
Enzymes (Maltase, Catalase, Oxidase and Invertase)	15, 18
Organic acids (Malic acid and Succinic acid)	18
Miscellaneous (Betaine, Tannins, Crude pigments)	15, 18

Table 2 — Comparative nutritional constituents of mahua flowers with other fruits

Per 100g	Apple	Mahua flower (Ripe)	Banana (Ripe)	Mango	Mahua flower ♦ (Dry)	Raisins
Moisture*	84.6	73.6	70.1	81	11.61	20.2
Protein*	0.2	1.4	1.2	0.6	6.67	1.8
Fat*	0.5	1.6	0.3	0.4	0.09	0.3
Minerals*	0.3	0.7	0.8	0.4		2
Fibre*	1		0.4	0.7	1.9	1.1
Carbohydrates*	13.4	22.7	27.2	16.9	68	74.6
Energy (Kcal)	59	111	116	74		308
Calcium**	10	45	17	14	139	87
Phosphorus**	14	22	36	16	137	80
Iron**	0.66	0.23	0.36	1.3	-	7.7
Carotene (µg)	0	307	78	2743	-	2.4
Thiamine**	-	-	0.05	0.08	0.028	0.07
Riboflavin**	-	-	0.08	0.09	0.87	0.19
Niacin**	0	-	0.5	0.9	4.8	0.7
Vitamin C**	1	40	7	16	-	-
Choline**	321	-	-	-	-	-

* -g/100g, **- mg/100g
 Source: Nutritive value of Indian foods, National Institute of Nutrition, Hyderabad⁶
 ♦ Source: Jayasree *et al*¹⁰

Table 3 — Essential amino acid pattern of mahua flower compared to wheat, soy, skim milk and FAO/WHO (1990) for evaluating proteins

Amino acid (g/100g protein)	Mahua*	Wheat♦	Soy♦	Skim Milk♦	FAO♦
Isoleucine	7.91	3.8	4.7	5.6	2.8
Leucine	12.98	6.6	7	9.8	6.6
Lysine	4.67	2.5	6.3	8.2	5.8
Phenylalanine	6.4	4.5	4.6	4.8	
Tyrosine	3.94	3	3.6	5	6.3
Cystine	3.35	2.2	1.4	0.9	2.5
Methionine	1.8	1.7	1.4	2.6	
Threonine	5.86	2.9	3.9	4.6	3.4
Valine	7.25	4.7	4.9	6.9	3.5

* Source: Jayasree *et al*¹⁰

♦ Source: Dini *et al*¹⁶

of wheat, soy, skim milk and FAO data¹⁶. The fat content of dry flowers^{6,8,9,10} varies from 0.09-1.3%. Detailed fatty acid composition of mahua flower fat resembles that of mahua kernel oil¹⁷. Different minerals reported in the flower^{8,9,10,18,19} are: calcium (0.14-0.25%), phosphorus (0.13-0.14%), iron (0.015-0.03%), potassium (1.2%), sodium (0.02%) and magnesium (0.21%). Apart from it, adequate quantity of different vitamins like thiamine, riboflavin, niacin, folic acid and ascorbic acid are also reported in the flowers^{6,9,10,18}. Enzymes like amylase, maltase, invertase, catalase and oxidase were detected in different stages of flower development¹⁵. Ascorbic acid oxidase was detected due to the high rate of degradation of the vitamin C content in the storage experiments¹⁸. In the miscellaneous test, succinic acid, betaine, malic acid, crude pigments and tannins were also detected¹⁸. It is also reported that the peculiar unpleasant odour of mahua and its spirit is due to an essential oil¹⁵.

Nutritional and medicinal properties

Review of literature on chemical composition of mahua flower reveals its high nutritional value. Apart from being a rich source of sugar and protein, the flowers also contain essential minerals like Ca, P, Fe and K. Calcium is the major component of bone and assists in teeth development²⁰. Phosphorus is next in importance to calcium as utilization of calcium is closely related to it. Most of the calcium in the body is deposited as calcium phosphate⁶. Iron is an essential element for the formation of haemoglobin of red cells of blood⁶. Vitamins like riboflavin and niacin content of the flower is more than that of apple, banana, mango and raisin (Table 2). Riboflavin as a part of a coenzyme is essential

for several oxidation processes inside the cell and is concerned with energy and protein metabolism⁶. Among several B-complex vitamins, riboflavin deficiency is most widespread, particularly among women and children in India, as it is the most limiting of all B-vitamins in cereal-based diet of the poor⁶. Niacin is also an important vitamin intimately connected with several metabolic reactions. Lack of this vitamin in diet leads to the disease pellagra, characterized by soreness of tongue, pigmented skin and diarrhoea⁶.

In Indian system of medicine (*The Ayurveda*), the flowers are reported to be cooling, aphrodisiac, galactagogue, expectorent and carminative. They are also reported to be beneficial in heart diseases, burning sensation, biliousness and ear complaints. The flowers fried in *ghee* (clarified butter) are eaten by people suffering from piles²¹.

Traditional and Industrial uses

In spite of being a rich source of nutrition and easy availability in the rural areas these flowers are not very popular as food. Only a small quantity of flowers is consumed raw, cooked or fried in different parts of India²¹. Major quantity of flowers is used in the preparation of distilled liquors. The freshly prepared liquor has a strong, smoky foetid odour, which disappears on ageing. It is reported to excite gastric irritation and produce other unpleasant effects²¹. Apart from food and liquor, the flowers are also used as a source of cattle feed.

Sugar syrup

There are several reports on preparation of sugar syrup from dry mahua flowers²²⁻²⁵. The water extract of dried flowers was decolorized with different decolorization agents like slacked lime and activated charcoal before concentrating it to the desired concentration. Activated charcoal at a concentration of 3.5-5% was found to be the best decolorization agent for preparation of mahua sugar syrup^{24,25}.

Fermented products

Dried mahua flowers are an attractive source of fermented products due to the high sugar content. Preparation of mahua wine from fresh flowers has also been reported²⁶. Various products like alcohol, brandy, acetone, ethanol, lactic acid and other fermented product have been prepared from the dry mahua flowers²⁷⁻³⁹.

Other uses

Recently, bacterial synthesis of poly (hydroxybutyrate-co-hydroxyvalerate) using mahua flowers has been reported⁴⁰. According to a study the yeast extracted from

an alcohol factory compared favourably with torula yeast and was better than distillery yeast⁴¹. Lender⁴² isolated a new species of yeast, *Zygosaccharomyces mahwae*, from a culture in sterilized must, into which some of the drug was placed. Apart from that, production of organic manure by adding mahua flowers to the waste organic matter was also studied⁴³. Use of spent flowers (produced after fermentation and distillation) as cattle feed gave on whole favourable results as far as the health and milk production are concerned⁴⁴. Apart from these, a study also reports the development of a new anti-bacterial mahua flower agar medium⁴⁵.

Future perspectives

From the above review it can be concluded that mahua flowers are a rich source of wholesome

nutrition and can be utilized as a food supplement (after suitable post harvest processing) especially for the malnourished people in rural areas.

In our study we selected fresh mahua flowers for value addition. The samples were collected from Sambalpur district of Orissa and processed immediately after collection. About 70-80% of a low acid juice (pH 5.9-6.2) was extracted from the fresh flowers and concentrated to desired Brix⁴. As a part of the Doctoral thesis, detailed scientific investigations (analysis of nutrient content, study of antioxidant property, safety study on animal model, shelf life study and sensory evaluation) were carried out for the developed mahua concentrate (Plate 1)⁴. Experimental findings shows that the developed concentrate is a

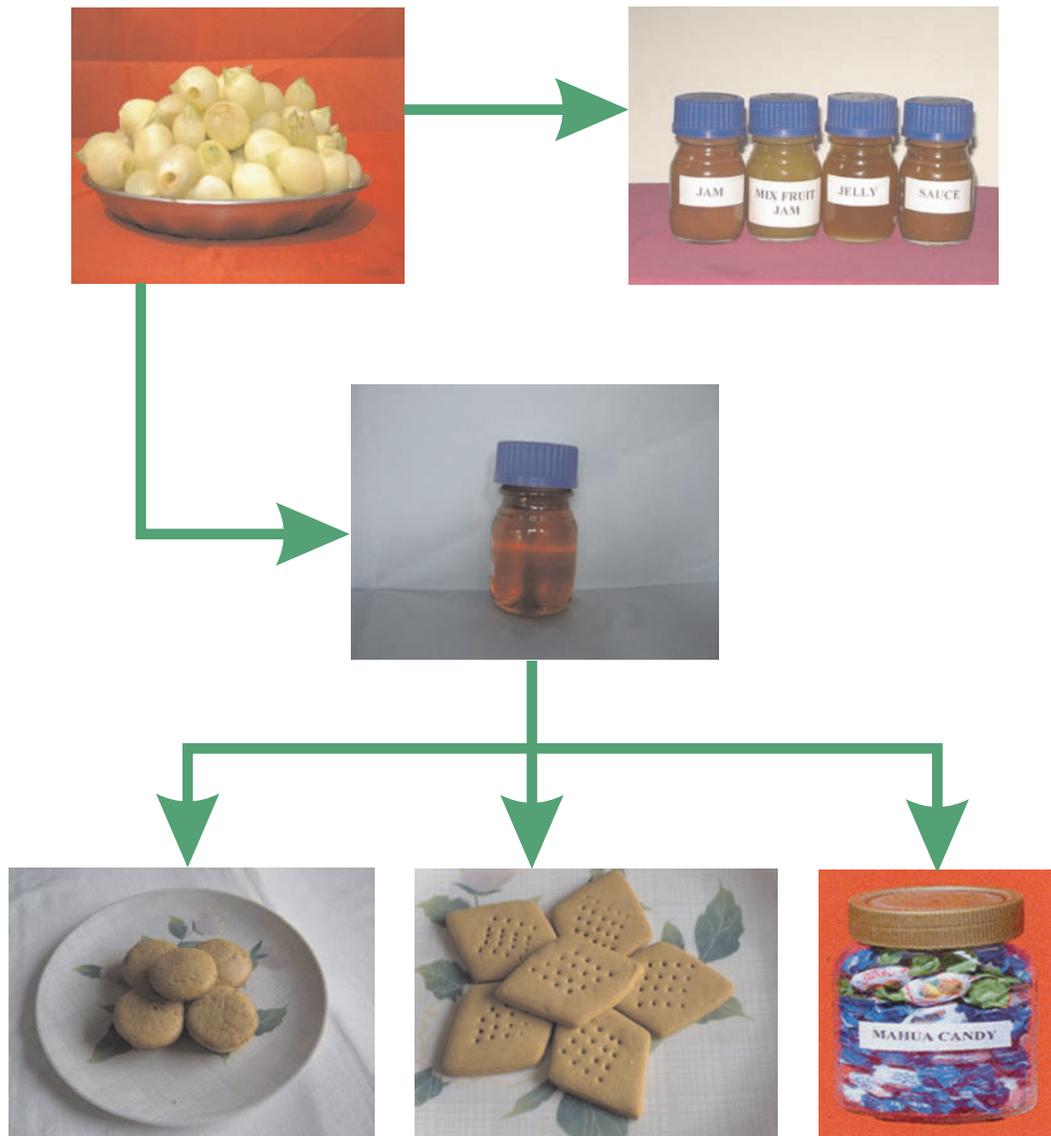


Plate 1 — Products developed from fresh mahua flowers

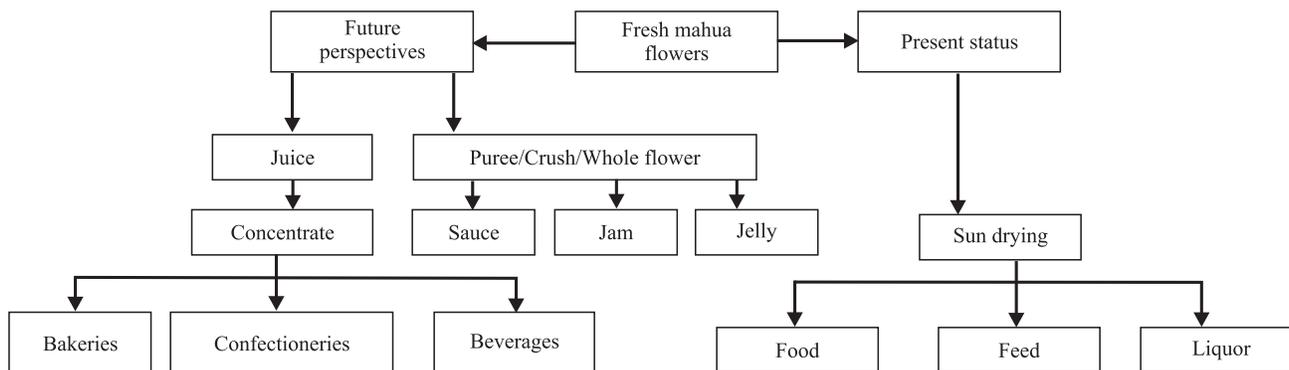


Fig. 1 — Flowers of *Madhuca indica*: Present status and future perspectives

rich source of reducing sugars (glucose and fructose) with high antioxidant activity. Results of sub-acute toxicity study on albino rats found the product to be safe for human consumption. Further, experiments were carried out to find the utility of the developed concentrate. Excellent bakery and confectionary goods (candy, biscuits and cake) were prepared using the mahua concentrate as a liquid sweetener⁴. Apart from extraction of juice, the fresh flowers were crushed to puree (after manually removing the stamens) and processed into sauce⁴. Mahua jam and jelly were also prepared using fresh flowers (Plate 1)⁴. The developed products were tested for their colour, flavour, taste, texture and overall acceptability, using hedonic test⁴⁶. According to the findings of hedonic test all the developed mahua products were found to be highly acceptable.

Basing on the literature survey and our experimental findings, a flow chart has been prepared and shown in Figure 1.

Conclusion

According to our experimental findings, the existing unhygienic collection and processing practices are the major factors affecting the food quality of nutritious mahua flowers. Open yard sun drying of the flowers, changes its colour as well as odour, resulting in the overall quality degradation. Extraction of juice from the fresh flowers and its immediate processing to prepare a liquid concentrate may be a possible solution to the above problem. The prepared concentrate can be stored and used as a sweetener in preparation of various food products. This way a considerable quantity of flowers can be processed into nutritious food supplements instead of only liquor production. Diversion of a part of these flowers for food processing may increase the employment and income generation potential for the mahua collectors apart from providing an affordable source of nutrition.

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