CHAPTER I

INTRODUCTION

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Introduction

In India tribals constitute approximately 7% of the population. Gujarat, with a total population of approximately 27 millions, has a tribal population of about 14 percent (Govt. of India Publication 1971). A variety of minor forest products partially meet the dietary requirements of tribal population living in or around forests. Several forest fruits, flowers, leaves, tubers and roots are eaten by the tribals. Scarcity of food, which is a common feature in tribal population, compel/s them to survive on wild edible plants(National Commission on Agriculture 1976). Some of these wild plants are consumed even as staple foods (Singh and Arora 1978).

Edible plants/products from Indian forests other than Mahuda flowers

Information on nutritional composition and consumption frequency of uncultivated edible forest products is scanty. However, an attempt has been made to put the available literature together. The nutritional composition of some of the edible forest products is available but for others, no such information could be found except that they are consumed by tribals whenever the forest products are seasonally available. Pingle(1975) has reported that tribals sun dry and store a variety of wild and seasonal plant products to be utilised during food scarcity and agriculturally lean months. The available information on edible forest plants is presented below.

a) Buch-Ham(<u>Natsiatum herpeticum</u>) plant is found in the forests of Himalayas (from Nepal to Sikkim), North Bengal, Bihar and Orissa. The leaves and tender tuberous roots of the plant are cooked and eaten, specially with fish(Wealth of India 1966).

b) Indian lotus (*Nelumbo nucifera*) plant commonly referred to as Kamalkakadi or Bhen is found throughout India. The plant is known for its edible rhizomes and seeds. The farinaceous rhizomes of the plant are fleshy and are used as vegetable. Freshly cut rhizomes are eaten after roasting, while dried ones are used in preparation of curry and pickle (Moorjani 1951). Kamalgatta the fruiting torus of the plant, is often used as a major food component. The edible carpels embedded in it, are round, oval or oblong and hard, and dark brown in colour. They are eaten as raw, roasted or boiled. The kamalgatta is ground into flour which resembles arrowroot flour in cooking. Because of its high carbohydrate (67%) content, the dried kamalgatta is considered superior to cereals in its nutritive value (Moorjani 1951).

c) Blue water lily (*Nymphaea stellata*) is found throughout the year in ponds and ditches particularly in the warmer parts of India. Various parts of the blue water lily plants are considered edible. The ovoiform, egg sized rhizomes, tender leaves and flower perduncles of these plants are used as vegetable. The rhizome is consumed after boiling or roasting. In times of scarcity, the seeds are made into flour and eaten admixed with wheat or barley flour (Pathak 1926).

d) Pardeshi-tadio (*Nypa fruticans*) or Nipa palm, forms gregarious growth in tidal forests of South India. The Nipa palm is mainly used for making home made jaggery. It is valued for the sweet liquid collected from the stem of the spadix which contains 17% sucrose. The tender stem buds are eaten as vegetable and young peduncles and immature seeds which contain nearly 20% starch are eaten as raw or are cooked (Das 1950).

e) In the various parts of Bengal, Assam, Bihar and Orissa, Sankalu(*Pachyrrhizus erosus*) a coarse, hairy twiner plant with large fleshy tuberous roots is occasionally found. Patnaik (1955) reported that the young tubers have a crisp, juicy and refreshing flesh which can be eaten as raw or are cooked while the mature tubers yield starch of superior quality and are used only as fodder.

f) Both, the purple and yellow varieties of passion fruit(*Passiflora edulis*) plants are found in North and Eastern parts of India. They are rich in sucrose, ascorbic acid and carotene. The fruits are eaten as raw or are cooked (Pruthi 1963).

The nutritive composition of some of the edible forest products is outlined in Table 1.1. The carbohydrate and protein contents of Kamalgatta and Blue water lily seems to be 4 to 5 times higher than that of Kamalkakadi, Sankalu and Passion fruits. The ripe fruits of both the varieties of Passion fruits are relatively rich in sugars and are eaten fresh, as dessert after meal(Pruthi 1962).

Consumption of various edible forest products by Indian tribes

The forest is one of the most important and bountiful sources of food and income for the tribals. Available literature indicates that tribals generally include seasonally available edible forest products in their dietaries. Shah(1950) investigated food intake of Dubla tribal community residing in Varad village of Surat District of Gujarat state. He reported that the tribals generally survived on available and seasonal forest products such as wild fruits and vegetables like Bora(*Zizyphus jujube*), Turbuj(*Citrullus vulgaris*).

Table 1.1 Nutritive composition of edible forest produces

	Kamalkakdi (*Nelumbo nucifera*)	Kamalgatta (*Nelumbo carperis*)	Blue water lily (*Nymphaea stellata*)	Sankalu (*Pachyrrhizus erosus*)	Passion fruit (*Passiflora edulis*) Purple variety	Passion fruit (*Passiflora edulis*) Yellow variety
Moisture %	87.90	10.90	4.20	82.38	20.40	89.00
Crude protein %	2.70	17.20	14.60	1.47	0.80	1.20
Crude fat %	0.10	2.40	0.50	0.09	0.05	0.20
Carbohydrate %	11.20	66.60	57.49	17.09	17.30	NR
Sucrose %	0.41	4.10	NR	5.20	10.00	7.70
Reducing sugars %	1.56	2.40	NR	2.17	4.60	NR
Fibre %	0.80	2.60	5.45	0.54	0.05	1.20
Ash %	1.10	3.00	7.85	0.50	NR	NR
Mineral matter %	0.50	0.70	NR	NR	0.45	0.70
Reference	(Moorjani 1953)	(Moorjani 1951)	(Pathak 1920)	(Pat Nial 1965)	(Pruthi 1963)	(Pruthi 1963)

NR = Not Reported

Sitaphar(*Annona squamosa*), Kakdi(*Cucumis sativus*), Ambadi(*Hibiscus subdariffa*), Kadu Kanda(*Dioscorea bulbifera*), and Amba(*Mangifera indica*). As a result, their diet was found to be poor in both, the energy yielding as well as 'protective' foods. In another study he (Shah 1959) reported that the staple diet of Naikas of Gujarat consisted of cereals like jowar(*Sorghum vulgare*), Bajra(*Pennisetum typhoideum*) taken in the form of liquid 'ghensh' (porridge) or Rotla(Unleavened bread). They also eat available forest fruits like Amla(*Emblica officinalis*), Jambu(*Syzygium cumini*), Van jambudi(*Syzygium rubicundum*) and Tadi(*Phoenix sylvestris*), along with cereals.

Later in 1964, Shah reported that the *Dhankas* tribe of Gujarat include wildly grown green leaves like Lakhoribhaji(*Lathyrus sativus*), Dhopa(*Colocasia antiquorum*), Chinche chapala(*Tamarindus indica*) and Tarota(*Cassia tora*) in their dietaries. These vegetables are eaten along with porridge or gruel made out of rice or jowar grain.

Saxena(1981) listed the various forest produces consumed by the tribals of Chhotaudepur district, Gujarat, in the peak and the lean seasons. During the peak season (in months of April and May), the tribals collect Mahuda flowers (*Madhuca indica*), Timru(*Diospyros melanoxylon*), Khalhara(*Butea monosperma*), Charoli(*Buchanania lanzan*), Chauri(*Ceriops candolleans*) and Kovaria(*Fettid cassia*). While in the lean season (in months of September and October) they collect Bore(*Zizyphus mauritiana*), Rayan(*Manilkara hexandra*).

Fang (*Rivea hypocrateriformis*) and Jharalmala(*Amaranthus gangeticus*).

The Korkus tribe(Census of India 1961) is found on both sides of the Saputara hill range with a heavy concentration in Nimar, Betul and Chhindwada districts of Madhya Pradesh and Melghat tahsil in Amravati district in Maharashtra. They eat Jowar rotla with dal or vegetable like Kodo(*Paspalum scrobiculatum*), Kutki(*Celsia coromondelinavani*) and leaves or roots of various plants cooked as vegetables. More recently Bhagat(1980) has reported that the Korkus survive on the meat of rats, serpents, birds and on amla in times of food scarcity.

Pingle(1975) reported diet pattern of the Koyas and the Maria Gonds of Central India. The Koyas live on millet based diet while Maria gonds commonly eat rice based diet. Both the tribal groups sun dry and store a variety of wild and seasonal vegetables, tubers, flowers(Ambadi, Mahuda flower), bamboo shoots and mushrooms.

The staple food of Kolis dhors of Maharashtra is Rice, Nagli(*Eleusine coracona*) and a Vari(*Panicum milliaceum*). However, in off seasons when the stock of food grains falls low, poor families subsist on the available wild fruits like berries, amla, tendu and shingada(*Trapa bispinosa*) and Mahua flowers(Pingle 1975).

The Kolam tribes living in Chandrapur district (Mane 1984) eat pej, gruel of rice flour with various edible plants such as Ratalu(*Dioscorea alata*), Matalu (*Hibiscus cancellatus*), Surankand(*Amorphophallus campamulatum*), Kariand (*Dioscorea bulbifera*), and Gadda (bamboo shoots). During food scarcity Mahua flowers are consumed as their staple food.

A survey by Gupta and Biswas (1958) on the diet and nutritional status of the five tribes of Travancore, the Kanikkar, Malapandaram, Ulladan, Muthuvan and Urali of South India revealed that the Kannikar, Urali and Malapandaram lived mainly on tapioca, yam and other tubers. Raghavan (1954) explored the diet pattern of Chenchus, a tribe of Andhra Pradesh. He reported that the tribals consumed tubers and leafy vegetables collected from the forest as staple food. Also, they collect and store Mahuda flowers to utilize in the lean season. Singh and Arora (1978) have reported that during food scarcity the tribals consume various fruits, seeds and flowers such as Jackfruit, Poppy and Rajkeera seeds, Jambu and Mulberry fruits; Honey and Mahuda flowers obtained from forest areas.

The nutritive content of some of these forest products (Gopalan et al 1981) are presented in Table 1.2. Rajkeera seeds, Honey and Mahuda flowers are rich source of carbohydrates (62.7, 79.5, and 72% respectively). The protein content of Poppy and Rajkeera seeds is relatively higher than that of Jack fruit, Jambu, Mulberry as well as Mahuda flowers. Also Poppy and Rajkeera seeds and Mahuda flowers seem to be a good source of minerals like calcium, phosphorus and iron. Fruits like Jambu and Mulberry contain good amount of carotene and ascorbic acid.

Nutritional studies on edible plant products

Many uncultivated edible plant products are known to contain anti-nutritional factors. Although, some of them are rich source of either carbohydrates or protein, yet their utilization is limited as they contain anti-nutritional/limiting factors that on ingestion, cause growth arrest and exert specific toxic effects. However,

Table 1.2 Nutritive content of various fruits, seeds and flowers consumed by the tribals

Name of food stuff	Edible portion (%)	Mois ture (g)	Pro tein (g)	Fat (g)	Mine rals (g)	Fibre (g)	Carboh ydrate (g)	Energy (K cal)	Cal cium (mg)	Phosp horus (mg)	Iron (mg)	Caro tene (mcg)	Niacin (mg)	Vita min (mg)
All the values given are per 100 g of edible portion														
Jack fruit (Artocarpus heterophyllus)	30	76.2	1.9	0.1	0.9	1.1	19.8	88	20	41	0.5	175	0.4	7
Jambu fruit (Syzygium cumini)	75	83.7	0.7	0.3	0.4	0.9	14.0	62	15	15	1.2	48	0.2	18
Mulberry (Morus sp.)	100	85.5	1.1	0.4	0.6	1.1	10.3	49	70	30	2.3	57	0.5	13
Jack fruit seeds (Artocarpus heterophyllus)	NR	64.5	6.6	0.4	1.2	1.5	25.8	133	50	97	1.5	10	0.3	11
Poppy seeds (papaver somniferum)	NR	4.3	21.7	19.3	9.9	8.0	36.8	408	1584	432	NR	NR	NR	NR
Rajkeera seeds (Amaranthus paniculatus)	100	9.2	16.5	5.3	3.5	2.7	62.7	364	223	655	17.6	NR	1.6	0
Honey	NR	20.6	0.3	0.0	0.2	NR	79.5	317	5	16	0.9	0	0.2	4
Mahuda flowers (Bassia latifolia)	87	18.6	4.4	0.6	2.7	1.7	72.0	311	140	140	15.0	33	5.2	7

Gopalan et al 1981
NR = Not Reported

tribals and others of lower socio economic groups, particularly during agricultural slack periods, do consume some of these non-conventional plant foods and also utilize them for animal feeding (Menon 197[illegible]). If these plant products are made free of anti nutritional/limiting factors by the use of appropriate processing procedures, a lot of our food problems could be minimised. Available literature regarding some such plant products is presented below.

a) Cassava (*Manihot utilissima*) is a shrubby tree of the euphorbiaceous family and has achieved considerable agricultural imporatance as the major source of tapioca (cassava roots) (Nestle 197[illegible]). But Cassava contains appreciable amounts of cyanide therefore consumption of Cassava roots by humans and animals has resulted in development of endemic goitre and cretinism (Ermans et al 1980). Bourdoux et al (1980) have reported that this anti-thyroid action of Cassava tuberous roots is mainly due to the endogenous release of thiocyanate (SCN) from linamarin, a cyanogenetic glycoside present in Cassava roots.

b) Khesari dal (*Lathyrus sativus*) is an easily grown pulse possessing a rich source of lysine, and in India it is abundantly found in Madhya Pradesh, Bihar and Uttar Pradesh (Rao et al 1964). But it contains β-N-oxalyl-L-α-β-diaminopropionic acid, a neurotoxic compound, which on excessive consumption, produces lathyrism in humans which is characterised by progressive spastic paralysis of the legs leading to permanent crippling (Swaminathan 1974). However, the consumption of small quantities of Khesari dal has been considered harmless(Gopalan et al 1981).

c) Kochia(*Kochia scoparia*) is a drought resistant uncultivated plant that produces high yields of seed containing nearly [illegible]% protein (Coxworth et al 1969). The protein quantity and quality (Van Etten et al 1963) of Kochia seeds and its oil content (Earle and Jones 1962, Coxworth et al 1969) suggest that Kochia seeds could be considered as a good source of protein and energy food. But weanling mice fed diet containing 7% Kochia seeds exhibited loss of appetite and growth arrest (Coxworth et al 1969). Souto and Milano(1966) had earlier demonstrated presence of saponins in mature Kochia seeds which probably could have caused growth arrest in mice observed by Coxworth et al (1969).

d) Chawla (1974) reported that although total digestible nutrients of Sal(*Shorea robusta*) seed meal amounted to 41%, the high content of tannins in sal seed meal limited its utilization in animals and poultry feed. However, Shukla and Jalpota (1975) have opined that in time of acute shortage of conventional feeds, sal seed meal could be incorporated upto a level of 40% in the diet of adult animals to meet their maintenance requirements.

e) Cotton seed(*Gossypium herbaceum*) cake was found to be valuable for feeding cattle and sheep because of their high protein content(Lawhon 1962). But high levels of gossypol(0.85 to 1.2% in Cotton seed cake) limited its use as poultry feed. Vix et al (1971) reported that inclusion of Cotton seed cake in the diet led to depressed food intake in broilers. Later in 1977, Achaya reported that the free gossypol rendered lysine unavailable because of its reaction with the terminal amino group of lysine.

f) Castor seeds(Ricinus communis) cake contain about 30% protein but have three toxic substances, viz. ricin (a heat liabile protein), ricinine(a toxic alkaloid) and a heat stable strong allergen (Menon 1977). The author stated that on ingestion the ricin present in castor cake (nearly 6 mg/kg of meal) agglutinized mammalian red blood cells and produced vomiting, colic, haemorrhagic gastroenteritis, convulsions and led to circulatory collapse.

g) Rubber seeds(Hevea brasiliensis) contain 20% protein and like khesari dal, are rich in lysine (Wealth of India 1962). But the seeds contain a cyanogenetic glycoside, linamarin and also a specific enzyme linase which hydrolyses the glycosides producing hydrocyanic acid, a well known poison (Ferrando 1981). There are contradictory results regarding the incorporation of rubber seed meals in poultry feeds because of the presence of toxic glycoside. But, rubber seed meal has been used as a protein concentrate in cattle rations (Menon 1977).

h) Rape and mustard(Brassica juncea) seeds are cultivated throughout India. Usually no distinction is made in trade and commercial statistics between the two as an oil seed crop(Menon

1977). The glucosinolates content in seed is the most important limiting factor in the use of rape and mustard meals as feed. On hydrolysis, glucosinolates with the presence of an endogenous enzyme myrosinase, give allyl isothiocyanate which is a goitrogenic substance and also causes palatability problems. In poultry, use of 20% mustard seed had been shown to result in high mortality due to massive liver haemorrhage (Rutkowski 1971).

c) It has been reported by Cauch (1967) that guar meal contains nearly 40% of crude protein and is a rich source of amino acids. But when its level in the diet exceeded 1.8%, it led to depressed growth in animals and produced sticky droppings in birds.

As stated earlier, these plants and their products, have high nutritive value, but exhibit limited usefulness because they contain anti-nutritional factor/limiting factors. However, some of these plants and their products can be processed to make them suitable for human and animal consumption.

Detoxification processes employed to remove the limiting factors of plant products

Processing of foods before consumption increases stability, improves flavour and decreases the possibility of toxicity. Bressani (1983) has opined that appropriate and well controlled processing helps in retaining the original nutrient content of the food and maintaining overall quality of the product.

Cooking in boiling water or in steam pressure is a common household practice to make foods palatable and safe for human consumption. Apart from this, cooking is known to inactivate practically all the anti-nutritional factors that are heat labile(Deosthale 1984). Cooking of food improves the biological value of protein. Udyasekhara Rao and Belavady(1979) have shown that the growth performance of rats was better when fed on cooked than on uncooked or raw diets. The growth performance of rats fed raw or cooked diet is presented below :

Growth performance of rats fed raw and cooked diets

	Weight gain (g) in 21 days	
Diet	Raw	Cooked
Soya bean	29	94
Winged bean	31	67
Potato	20	38
Winged bean tuber	died	21

The authors observed that the rats fed on raw diets failed to grow and showed a significant loss in body weight and those fed on the tubers even died. However, growth responses improved when rats were fed on cooked diets. The authors attributed the better growth performance in rats fed on cooked diets to the destruction of the anti-nutritional factors present in those foods. Polyphenolic compounds, phytic acid, cyanogenetic glycosides etc. present in grains act as nutritional inhibitors and these get destroyed when the grain is cooked. Liu et al (1980) and Chi-yuen Chou(1981) have demonstrated the processing that removed the anti-nutritional factors such as trypsin inhibitor, saponin and haemagglutinin from soyabeans. The authors reported that the process of overnight soaking of soyabeans followed by pressure cooking at atmospheric pressure for 10 minutes, detoxified the toxic compounds consequently the beans were found to be safe for consumption.

Hourdox et al (1980) investigated the effects of boiling on cyanide content of Cassava leaves and roots. The cyanide content of fresh Cassava leaves was reduced from 68.6 to 7.7 mg/kg on boiling in water for 15 minutes(Table 1.3). The cyanide content was further reduced to 1.2 mg/kg when the boiling period was increased from 15 to 70 minutes. Likewise the cyanide content of fresh roots(sweet variety) decreased from 19.7 to 1.7 mg/kg on boiling the roots in water for 20 minutes. Fresh Cassava roots of sweet and bitter variety had cyanide content of 111.5 mg/kg which on sun drying reduced to 15.7 mg/kg. The authors concluded that sun drying alone was less efficient a process to remove cyanide from Cassava foods. Because there was nearly a complete detoxification of cassava leaves and roots when they were boiled in water for 70 minutes. Nambisan and Sundresan (1982) assessed the efficiency of pre-soaking of cassava roots at 35° - 40° C for 10 minutes before boiling them for 20 minutes and found that the cyanide content had decreased to 50% of their original value. The authors stated that since Cassava tuber contains both cyanogenetic glycoside and its hydrolysing enzyme linamarase, pre-soaking at 35-40° C favoured degradation and removal of the glycoside as cyanide(HCN) which led to a considerable decrease in cyanide content.

To remove tannins from Sal meal several methods have been tried such

Table 1.3 Cyanide content of fresh and processed Cassava foods

Processing procedure	Remaining HCN (mg/kg)	%
	MEAN ± SE	
Fresh leaves	58.6 ± 22.9	100.0
Dried leaves	56.1 ± 40.2	96.2
Boiled leaves (15 minutes in water)	[illegible].7 ± 2.2	5.4
Boiled leaves (30 minutes in water)	1.2 ± 0.8	1.7
Fresh roots (sweet variety)	10.7 ± 4.8	100.0
Boiled roots (20 minutes in water)	1.3 ± 1.7	12.1
Fresh roots (sweet & bitter variety)	111.5 ± 70.2	100.0
Sun dried roots (sweet & bitter variety)	15.7 ± 21.5	14.1

Bourdoux et al (1980)

as cold water processing, boiled water processing, acid, alkali and salt treatment, ethanol, methanol and acetone treatments and treatment involving combination of acid and alkali. Sal meal processed with ammonia was reported to be the simple method to depolymerise and inactivate tannins present therein without any loss of solids(Reddy et al 1978).

Acton(1922) was the first worker to point out that Khesari dal soaked in three changes of water became non-toxic. The author explained that the toxic factors present in Khesari dal leached out in water making the dal free of its toxic matter. Nagarajan et al (1965) have demonstrated that the toxic factors can be removed by either cooking the seed or cooking the seed in excess of water and draining off the excess water or steeping the whole seed or decuticled seed in hot water(60-70° C) for 4-5 hours and rejecting the soak water. However, the authors explained that the former process can be carried out at home level while the latter can be used only in the industrial scale.

The effectiveness of caustic soda washing to improve the feed value of Kochia seeds was investigated by Coxworth and Salman(1972). The authors demonstrated that caustic soda washing destroyed saponin content of mature Kochia seeds. Further more, they reported that diets containing 15% caustic soda washed Kochia seed produced as good performance as the control diet in growth trials on turkey birds.

Lawhon(1962) soaked cotton seed flakes in aqueous acetone prior to oil extraction and reported that the treated meal had exceptionally low gossypol content. Also, Vix et al (1971) treated cotton seed flakes with aliphatic amines followed by extraction with a liquid cyclone and reported that this method removed large amounts of the free and bound gossypol. Fresh rubber seeds contain poison called hydrocyanic acid (200 mg/100 g seeds) which could be eliminated by repeated soaking of the seeds (Menon 1977). The author opined that after repeated soaking, the rubber seeds should also be subjected to 20 minutes of drying.

To detoxify the mustard seed meal, addition of water to the meal followed by steam volatilization for 10 minutes has been suggested by Rutkowski (1971). In this process all the residual thioglycoside present in mustard meal are converted to allyl isothiocyanate, which are safe and non-toxic to the body. Also, the author reported that mustard meal so processed when fed at high levels(20%) to poultry had shown satisfactory growth performance.

Table 1.4 summarises various plant materials, their toxins/limiting factors and detoxification processes employed to make them free from their toxic matters. The usefulness of these plant products is limited because of the fact that all of them contain toxins or limiting factors. However, various authors have reported detoxification processes to make plant products suitable for human and animal consumption(Table 1.4). For food containing toxins like cyanogenetic glycoside and linamarin, the processing methods that have been used are 1) sequential soaking and sun drying (Bourdoux et al 1980) and 2) repeated soaking of the seeds with changing of water, followed by steam volatilization and thereafter air drying

Table 1.4 Toxins/limiting factors of various plants and their detoxification processes

Plants/products	Toxins/limiting factors	Detoxification process	Reference
Cassava (<u>Manihot utilissima</u>)	Cyanogenetic glycoside, linamarin	Sequential soaking and sun drying	Bourdoux et al 1980
Khesari dal (<u>Lathyrus sativus</u>)	Lathyrogen	Overnight soaking, cooking in excess amount of water and draining off.	Mohan et al 1966
Kochia (<u>Kochia Scoparia</u>)	Saponins	NaOH washing	Coxworth and Salman 1972
Sal (<u>Shorea robusta</u>)	Tannins	Ammonia process which also increased non-protein nitrogen content of the meal	Gandhi et al 1975
Cotton seed (<u>Gossypium herbaceum</u>)	Gossypol	Extraction with aqueous acetone	Lawhon 1962
Castor seed (<u>Ricinus communis</u>)	Ricin, Ricinine, Allergens	8% lime addition to the meal and subsequent neutralization with phosphoric acid and drying	Menon 1977
Rubber seed (<u>Hevea brasiliensis</u>)	Cyanogenetic glycosides, linamarin	Repeated soaking of the seeds with changing water, followed by 30 minutes drying	Menon 1977
Mustard seed (<u>Brassica juncea</u>)	Glucosinolates, thioglucosides, Allyl isothiocyanate	Addition of water, followed by steam volatilization and thereafter drying	Rutkowski 1971
Guar (<u>Cyanopsis psoraloides</u>)	Trypsin inhibitor, guar, gum	Cooking the meal in water or autoclaving	Cauch 1967
Mowrah seeds (<u>Madhuca latifolia</u>)	Saponins	Acid hydrolysis and soxhlet extraction of the meal	Mulky 197[illegible]

(Rutkowski 1971). These methods have been used by Mohan et al (1966) to detoxify Khesari dal from its toxin namely Lathyrogen. Gandhi et al (1975) reported that to remove tannins from Sal seeds, ammonia process was efficient because the treatment not only detoxified the meal but at the same time it increased non-protein nitrogen content of the meal and made it more nutritious. Gossypol, could be removed by extracting cotton seed flakes with aqueous acetone(Lawnon 1962). For eliminating saponins from Mowrah seeds, Mutky (1976) has suggested acid hydrolysis and soxhlet extraction methods. Coxworth and Bolman (1972) have reported that caustic soda washing of Kochia seeds detoxified the toxin making the seeds suitable for consumption. Also, trypsin inhibitor from guar gum meal can be removed by either cooking the meal in water or by autoclaving(Lauch 1967).

It has been reported that the growth promoting qualities of cooked foods are superior to those of raw foods. This is mainly attributed to the destruction of anti-nutritional factors and also to the better utilization of nutrients like protein and carbohydrates (Deosthale 1984). Apart from wet heat treatment, the plant products are subjected to alkali, acid or combination of acid alkali wash to make them free of saponin, gossypol, tannins, ricin, ricinine and allergen toxins. Results of various studies have indicated that common beans contain polyphenolic compounds that interfere with protein digestibility and protein quality(Bressani and Elias 1979, Bressani et al 1981). Yadav and Liener (1978) had subjected common beans to the process of roasting to improve their protein quality. The protein quality of autoclaved and dry roasted Navy beans

(*Phaseolus vulgaris*) is presented below :

The protein quality of autoclaved and dry roasted Navy beans

Autoclaving(minutes)	Trypsin inhibitor	Haemagglutination units/g x 10^{-3}	PER
0	16.5	75.5	
15	2.5	0.[illegible]	1.69
30	0.0	0.0	1.46
60	0.0	0.0	1.15
Dry roasted(20-25 seconds at 196-200°C)	4.1	0.[illegible]	1.82

Navy beans autoclaved for 15 minutes exhibited PER of 1.69, but when the autoclaving time was increased from 15 to 30 to 60 minutes the PER started to decrease from 1.69 to 1.46 and 1.15 respectively. However, roasting of beans for 20-25 seconds at 196-200° C improved the protein quality of beans over that observed for 15 minutes autoclaved beans (PER 1.82 vs 1.69).

Bressani et al (1977) compared weight gain of rats fed for 28 days on either autoclaved or drum dried or extruded cow peas. It was observed that the weight gain was higher in rats fed on extruded food and lower in those fed on autoclaved cow peas(75 g vs 44g). The protein quality of extruded processed cow peas as judged by PER was 2.12 and that of drum dried cow peas 1.97. The authors speculated that extrusion process might have caused a greater inactivation of antiphysiological factors and thereby increased the susceptibility of protein to a more complete hydrolysis or it might have changed the carbohydrate fraction to favour better protein utilization and in turn increased overall protein quality of cow peas.

Available literature on Mahuda flowers

Bassia latifolia or *Madhuca indica*, known in Hindi as Mahua and in Sanskrit as Atavimadhuka is one of the abundantly growing plants in India(Bhargava and Singh 1958). In Gujarat especially in Chhotaudepur and Panchamahal Districts, Mahuda trees are widely distributed in and outside forest areas(Abhyankar and Narayan 1942, Joshi 1979, Gopaldas et al 1985a). Mahuda tree is important to the hill tribes as it yields edible flowers and oil seeds in addition to timber and fire wood.

It has been reported that the tribals utilize all the parts of Mahuda tree such as seeds, fruits, flowers and bark(Wealth of India 1962). The seed of Mahuda tree locally known as Doli yields about 40 to 50% edible oil(Joshi 1979). In some rural areas, the Doli oil is used for cooking as well as for lighting stoves(Gopaldas et al 1985b). It is also reported to be useful in the treatment of scurvy(Bhargava and Singh 1958). In addition, the oil is considered as an important raw material in manufacture of soap and candles (Joshi 1979). Mahuda seed cake however, is considered unsuitable for incorporation in animal feed because it contains saponin but the oil has been reported to be free from saponin (Mully and Gandhi 1977).

Saponins as a class are characterised by bitter taste, foaming property in aqueous solution and by their haemolytic activity (Walter et al 1955). They are used industrially as foaming agents in root beer and other frothy drinks(Marker and Lopez 1947). In rats, toxic effects of Mahuda seed saponin leading to death has also been reported(Menon 1977). But George (1965) had earlier reported the importance of saponins for the commercial synthesis of steroidal hormones.

Collection and storage pattern of Mahuda flowers among hill tribes

Mahuda is declared as a reserved tree under the Indian Forest Act. The local tribals have the privilege of collecting Mahuda flowers and fruits from forest areas, waste lands and from their own land for personal use and also for selling to authorised dealers(Joshi 1979).

Mahuda tree undergoes seasonal flowering. The ripe cream coloured flowers of Mahuda trees fall on to the ground in showers during the months of March to April. They are collected, spread on floor or mats and allowed to sun dry. Some times the flowers are allowed to dry under trees in shade. These flowers are considered to be organoleptically superior to those dried under sun(Joshi 1979). During the process of drying, the Mahuda flowers shrink in size and turn reddish brown in colour. On sundrying the flowers develop a charecteristic Mahuda odour (Wealth of India 1962).

The survey undertaken to find out storage practices of Mahuda flowers by the tribals of Chhotaudepur(Gonaldas et al 1983c) revealed that 66% of the families removed stamens before storing flowers because the stamens were considered as a waste product and were believed to be causing flatulence/diarrhoea. The cleaned, sun dried flowers were then stored in gunny bags, earthen bins, earthen vessels or bamboo basket. Some times Neem leaves were placed in between layers of the flowers to keep them insect free.

The fleshy corollas of the fresh and air dried Mahuda flowers contain large amounts of sugar and appreciable amounts of vitamins and calcium. As early as in 1886 Church analysed dried Mahuda flowers and reported that flowers contained 15.0% moisture, 67.0% total sugar, 2.4% cellulose, 2.2% albuminoids, 4.8% ash and 12.5% undetermined matter. Of the 67.0% total sugar, 52.6% was invert sugar, 7.2% cane sugar and 7.2% other matters soluble in water. An year later, Elworthy (1887) reported that Mahuda flowers contain 57% sugar. The total sugar content of the flowers was maximum when they were mature and ready to fall (Wealth of India 1962). In the growing stage, fructose was present in a greater amount than glucose and in the ripe stage the quantities of these sugars became almost equal. The amount of sucrose was found to increase upto the shedding of the corolla which later on got converted into invert sugar (Belavady and Balasubramaniam 1959).

Fowler et al (1920) had earlier determined carbohydrates content of Mahuda flowers at four different maturity stages. At the first stage the flower bud was completely closed, at the second stage, the bud was still enclosed but the style was seen protruding to about 1/4 to 1/2 inch and at the third stage, the flowers were partially open while at the fourth the flowers were considered fully ripe. At this stage the succulent cream coloured flower was about to shed. The sugar content of Mahuda flowers at different maturational stage and that of the stored flowers is presented below :

Sugar content of Mahuda Flowers at various stages

Stage	dextrose %	Levulose %	Cane sugar %	Total sugar %	Total invert sugar %
First	11.15	11.75	2.27	14.72	14.9
Second	6.76	11.63	2.60	22.04	22.[illegible]
Third	7.42	17.50	11.78	[illegible]	26.4
Fourth	18.24	20.12	28.80	67.56	69.0
Stored Flowers	15.54	[illegible].70	18.75	61.69	—

The authors concluded that the total sugar content increased progressively with the maturity of the flowers. The increase was larger after the second stage of maturity. The sugar content was highest when the flowers were about to fall off from the tree. However on storage, the percentage of cane sugar decreased, probably due to partial fermentation coupled with partial hydrolysis as the levels of dextrose and levulose tended to increase. Later Kutaria and Magar(1955a) had attributed the decreases observed in cane sugar of stored Mahuda flowers to invertase activity and those in reducing sugar to autofermentation of sugars.

Abhyankar and Narayana(1942) determined chemical composition of fresh and air dried Mahuda flowers and of Mahuda flower residue obtained after extraction of sugars. Their data presented in Table 1.5 indicate that the carbohydrate content of fresh flowers was nearly 20% while that of air dried flowers, it was 72%. Likewise, the total sugar content of fresh flowers was 18.5% whereas that of air dried flowers, it was 61. %. Of the total sugar content, reducing sugars estimate to about 76% to 87%. Kutaria and Magar(1955b) have examined the type of sugars in unhydrolysed and hydrolysed Mahuda flower extract and reported that the former

Table 1.5 Composition of Mahuda flowers

	Fresh flowers %	Air dried flowers %	Residue of flowers %
Moisture	77.57	19.57	4.81
Ether extractives	0.11	0.18	2.25
Crude protein	0.71	[illegible]	9.27
Carbohydrates	19.79	72.09	68.17
Reducing sugar	16.10	45.50	-
Non reducing sugar	2.40	14.90	-
Crude fibre	0.44	1.90	11.72
Ash	1.00	[illegible]	5.19

Abhyankar & Narayan (1942)

contained sucrose, maltose, glucose, fructose, arabinose and rhamnose while in the latter, sucrose was absent and instead galacturonic acid was detected.

Mahuda flowers contain appreciable amounts of vitamins and minerals. The vitamin content of flowers, as given in Wealth of India(1962) is presented below :

Vitamin contents of Mahuda flowers

Vitamins	Amount/100 g
Carotene (as vitamin A)	7[illegible] IU
Ascorbic acid	7 mg
Thiamine	12 mcg
Riboflavin	878 mcg
Niacin	5.2 mg
Pentothenic acid)	
Folic acid)	Amount not
Biotin)	stated
Inositol)	

It has been reported that 88% of the original ascorbic acid present in the Mahuda flowers was destroyed by ascorbic acid oxidase within one month of storage at the room temperature (28-[illegible]0° C). However, on storage no changes were observed in content of minerals and B group vitamins(Wealth of India 1962). Sutaria and Magar (1958a) demonstrated the presence of Calcium (145 mg%), Phosphorus(1[illegible]5 mg%) and Iron(47.5 mg%) in Mahuda flowers. Later Patel et al (1971) reported that Mahuda flowers contain 0.95 PPM molybdenum and 1[illegible].55 PPM zinc on dry matter basis.

Common uses of Mahuda flowers

a) **In Liquor Preparation**

Mahuda flowers because of their high sugar content, have been primarily used for preparation of fermented products such as liquor and vinegar. It has been reported that next to molasses, Mahuda flowers constitute the most important raw material for alcohol production. The freshly prepared liquor has a strong, smoky foetid odour which disappears on ageing. Redistilled and carefully prepared Mahuda liquor has been considered to be of good quality, closely resembling Irish whisky(Trotter 1940). In recent years, utilization of Mahuda flowers for the alcohol production decreased due to mainly the increased use of molasses as raw material. However, it has been anticipated that the use of Mahuda flowers for alcohol production will continue in localities where they are available at low cost and where alcohol is intented for use as a potable spirit(Wealth of India 1952, Chatterji 1944). In a more recent survey, Gopaldas et al (1983b) have reported that in the tribal area of Chhotaudepur in Gujarat state, the consumption of liquor per day was 500 ml by men and 250 ml by women among non Bhagats. The survey also revealed that non-bhagat tribal woman drank Mahuda alcohol during and after labour to feel relaxed. In addition, Mahuda liquor was believed to stop post partum bleeding and clean the women's gastrointestinal tract. However, in the special group of tribals, the young children below 6 years of age and pregnant women were prohibited from consuming Mahuda liquor. It has also been proposed that the waste from brew which contains 19% crude protein and 50% carbohydrate could be used as energy and protein supplying feed stuffs for cattle and poultry (Ranghan 1980).

b) As a food component

i) Trotter (1940) and Bhoura et al (1949) reported that Mahuda flowers were being eaten as raw or fried or baked into cakes. The authors observed that more often the flowers, after removing the stamens, were boiled for about 6 hours and left to simmer until the water evaporated completely. The odour disappeared as a result of cooking and the material became soft and juicy. It was eaten with rice, tamarind, sal seeds, grains or was consumed as such as a sweet. Earlier Abhyankar and Narayan (1942) had reported that both fresh and dried flowers were eaten extensively as such or after cooking.

Gopaldas et al (1983a,b) observed that non-bhagat tribals of Chhotaudepur, ate Mahuda flowers to their satiety. Roasted or crushed flowers were incorporated into dal and into the chappatis dough(unleavened flat bread). Occasionally the flowers were admixed with staple cereals such as maize(*Zea mays*), Bajra(*Pennisetum typhoideum*) or Kodri(*Paspalum scrobiculatum*). Sometimes the dried flowers were cooked with rice(*Oryza sativa*) and consumed. Also, it was reported (Gopaldas et al 1983c) that a few tribal families used Mahuda flowers as a substitute for filling tobacco in their beedies. However, due to a strong belief among the tribals of Chhotaudepur that Mahuda flowers when consumed cause diarrhoea, flatulance and other digestive problems the flowers formed a major food source only during the lean season and famine(Joshi 1979, Gopaldas et al 1983c). The pregnant or lactating women do not eat

Mahuda flowers because of the belief that it causes abortion(Gopaldas et al 1970b). It has been however, opined (Wealth of India 1962) that Mahuda flowers should be consumed in moderate quantities as excessive consumption may cause vomitting with cerebral symptoms.

ii) Mahuda flowers although contain negligible amount of pectin they have been used in jam preparation admixed with apples (Joshi 1979). Mahuda syrup has also been prepared and used in preparation of jam, sweets or has been used as a substitute for honey.(Wealth of India 1962). The degree of sweetness of Mahuda syrup was determined by Saxena in 1981. The Mahuda syrup was found to be 1.5 times less sweet than jaggery and 2.5 times less sweet than sucrose. The author prepared biscuits using Mahuda syrup as the sweetening agent and reported that organoleptically the biscuits were acceptable. Therefore the author suggested that Mahuda syrup could be used as sweetener in preparation of snacks.

c) **Medicinal use**

Mahuda flowers have been regarded as cooling tonic and demulcent. Also, the flowers have been used to control cough, colds and bronchitis. Kesari dal(Lathyrus sativus) which causes lathyrism was observed to be harmless when consumed along with flowers of Madhuca indica. Mahuda flowers have exhibited anti-bacterial activity against Escherichia coli. The honey prepared from the flowers was reported to be used for eye diseases. Also, the bark and roots of Mahuda tree have been used for controlling rheumatism, ulcers, itches, bleeding and spongy gums, tonsillitis and diabetis mellitus(Wealth of India 1962).

Since, Mahuda flowers are rich source of carbohydrate and vitamins it was envisaged that the flowers could serve as an important supplementary food for the tribals. But as mentioned earlier, the tribals appeared to be apprehensive towards the free use of Mahuda flowers in their dietaries which indicated that perhaps, they had some unpleasant experiences as a consequence of eating these flowers. Also, Mahuda seed meal contain toxic substance like saponin therefore, it was reasonable to believe that the Mahuda flowers being part of the same tree, might also contain some toxic substances. Earlier, Saxena (1983) had demonstrated growth retardation in Weanling rats fed for 28 days, diet containing biscuits which were made by using Mahuda syrup as the sweetening agent. The Mahuda biscuits were incorporated into the diet to supply 1/4th rat's daily energy requirements.

Recently, the Protein Advisory Group of United Nations (1980) has emphasised the need to establish safety of a novel food before it is recommended for human consumption. Thus it was considered necessary to establish the safe level of Mahuda flowers that could be used as an energy source initially on an animal model.

The present study was therefore planned with the main objective of exploring the possibility of using Mahuda flowers as a source of carbohydrate in the diet of vulnerable groups of rats.

Specific objectives of the study:

Since regional variations have been reported in nutritive composition of Mahuda flowers, the objective **one** was to determine nutritive composition of Mahuda flowers obtained from Chhotaudepur district of Gujarat state.

Since cooking of foods makes the food safe for human and animal consumption by destroying/decreasing the anti-nutritional factors such as trypsin inhibitor (Kumar et al 1980), Saponin (Liu et al 1980), haemagglutinins (Bender 1978), cyanogenetic glycosides and goitrogens (Delange et al 1982) present in various plant products, the **second** objective was to explore the effect of feeding pressure cooked for 10 or 20 minutes, Mahuda flowers as the source of carbohydrate, on growth and biochemical status of weanling rats. The **third** objective was to explore the level of Mahuda flowers in the diet, that would support growth in weanling rats when used as a carbohydrate source.

Since tribals of Chhotaudepur of Gujarat state refrain from eating Mahuda flowers during pregnancy and lactation the **fourth** objective was to investigate the effect of feeding pressure cooked Mahuda flowers as the source of carbohydrate on (a) the nutritional status of pregnant rats, on the products of reproduction and (b) on the lactational performance of the dams in terms of growth rate of pups unto weaning age.

As per the author's knowledge particularly in Mahuda flowers, the presence of saponin or any other toxic substance/anti-nutritional factor has so far not been reported, therefore the **fifth** objective was to (a) identify the presence if any, of anti-nutritional/toxic factor in Mahuda flowers. (b) conduct pharmacological investigations on isolated rabbit duodenum or stomach fundus of rat and (c) evaluate nutritional quality of steam treated Mahuda flowers. In all, five experiments were conducted to fulfil the above mentioned objectives. In experiment IV and V, respectively 2 and 3 separate studies were carried out.