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# The Role of Underutilized Fruits in Nutritional and Economic Security of Tribals: A Review

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*The tribal people of Rajasthan are severely malnourished along with multiple nutrient-deficiency disorders due to ignorance about importance of fruits and vegetables in their diets. The tribal areas are full of biodiversity having natural vegetation which is not harnessed fully. Due to which a wide gap is formed between health and optimal use of natural sources of nutrients, i.e., underutilized crops. The crops, which are neither grown commercially on large scale nor traded widely, may be termed as underutilized horticultural crops. These crops are cultivated, traded, and consumed locally. These crops have many advantages like easier to grow and hardy in nature, producing a crop even under adverse soil and climatic conditions. So, exploitation of underutilized horticultural crops can become a solution to the social problem of health and nutrition insecurity, poverty, and unemployment. The consumption of underutilized fruit crops can provide nutrition to the poor and needy tribals by meeting the nutrient requirements of vulnerable groups. As underutilized fruits, nuts, and vegetables are a rich source of carbohydrates, fats, proteins, energy, vitamins—A, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, B<sub>6</sub>, B<sub>9</sub>, B<sub>12</sub>, C, folic acid, and minerals—Ca, P, Fe, and dietary fiber. Thus, they have the nutritional capacity to prevent and cure various diseases like kwashiorkor, marasmus, night blindness, anemia, diabetes, cancer, hypertension, and hidden hunger. It is also established fact that seasonal, locally available, and cheap fruits and vegetables can also keep the population healthy and nutritionally secure rather than costly off-season ones. Also, the underutilized crops have the potential to give economic security to tribals by giving employment and by fetching good returns from their sale in raw form as well as value-added products.*

**Keywords** Underutilized fruits, nutritional security, economic security, tribals

## INTRODUCTION

The major tribal areas of Rajasthan state comprise Dungarpur, Banswara, Sirohi, Udaipur, and Jhalawar. The important scheduled tribes of state are Bhils, Gadia Lohar, Garasia, and along with some other *adivasis* that are found in different parts of Rajasthan like Bishnoi, Mina, Meghval, and Rabari. The *adivasis* are suffering from various deficiency diseases due to faulty eating habits, cultural myths and taboos for foods, improper dietary composition, poverty, ignorance, lack of awareness leading to malnutrition, and health insecurity. Undernutrition is found mostly in rural tribal areas and is concentrated in a relatively small number of districts and villages with 10% of villages and districts accounting for 27–28% of all underweight children (Anonymous, 2009). Undernutrition includes

both protein-energy malnutrition and micronutrient deficiencies. Undernourishment not only affects physical appearance and energy levels, but also directly affects many aspects of the children's mental functions, growth, and development which have adverse effects on children's ability to learn and process information and grow into adults that are able to be productive and contributing members of society. Undernourishment also impairs immune function leaving them more susceptible to infection. Children with infections are more susceptible to malnutrition and the cycle of poverty and malnutrition continues. Child malnutrition is responsible for 22% of India's burden of disease. The prevalence of micronutrient deficiencies varies in different areas, more than 75% of preschool children suffer from iron-deficiency anemia (IDA) and 57% of preschool children have subclinical Vitamin A deficiency (VAD). Iodine deficiency is endemic in 85% of districts, mostly due to the lack of iodized salt. Every day, more than 6000 children below the age of five die in India. More than half of these deaths are caused by malnutrition—mainly due to lack of Vitamin A, iron,

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iodine, zinc, and folic acid. About 57% of preschoolers and their mothers have subclinical VAD. (Anonymous, 2007a). Anemia prevalence among children under five years is 69% and among women it is over 55% in a recently concluded national study (Anonymous, 2007b). In this state 40.4% of children are underweight, 14.0% of the population is undernourished and 8.5% of children who die under the age of 5 due to hunger. In Rajasthan, the severity of the hunger situation is considered to be alarming (Anonymous, 2010a). Women and those living in poverty, especially in tribal areas, are at high risk of malnutrition. Those who live in rural environments have less access to markets in town where there are a variety of nutrient-rich foods. They also have less access to health care facilities due to limited transportation as well as public aid, 400 million people are living below the poverty line and 75% of them live in rural areas. Women are at a lower social level than men and therefore are at a greater risk because they are not valued equally. (Megan Blackman, 2005). With the scientific reality of anemia being a result of iron deficiency, these data reflect an almost universal iron deficiency in Indian population. The major source of energy and protein in their diets are cereals and pulses. But due to less consumption of fruits and vegetables, these people develop various micronutrient deficiencies. Hence, underutilized fruits and vegetables can be the best solution to fight this hidden hunger. India is the centre of origin for many tropical fruit tree species, most of which are not commercially cultivated but provide a significant source of livelihood support for many rural tribal communities. Besides their importance for their nutritional value and as a source of household income, this fruit diversity also has a cultural and social value and contributes to the stability of ecosystems (Arora, 1998). Aravali range is the oldest range of the world, which is the treasure of underutilized horticulture crops, and if exploited properly has the potential of transforming the economy of this tribal-dominated region of Rajasthan. As many as 150 tropical, 50 subtropical, and 20 temperate fruits hold considerable value and the potential of a veritable treasure of a large number of world's fruits still remains to be explored and underutilized (Arora, 1985; Pareek and Sharma, 1995a). Only a few have been cultivated on large scale, many fruit species have not yet been utilized to full potential in spite of their economic value. Some of the important underutilized fruit crops are Timroo, Piloo, Jamun, Sitaphal, Mahuva, Mulberry, Kainth, Ber, Ker, Karonda, Khirni, Date sugar, Tamarind, Bael, Aonla, etc., medicinal plants are Safed musli, Mulathi, Googal, *Aloe vera*, etc. and vegetables are Clusterbean, Kachri, Khip, Khejri pod, and Kakri are the main source of livelihood for the poor tribals and play an important role in overcoming the problem of malnutrition (Gajanana et al., 2010). These horticultural crops have remained underutilized since long. The main reason of being underutilized is the lack of awareness of their potential and low erratic bearing habit of these fruit plants. Besides, some of these fruits are not acceptable in the market in fresh form due to their acidic nature and astringent taste. Hence, there is a need to concentrate on research efforts in diversification and popularization of such underutilized fruit crops. Focused attention is essential

for improving and adopting the growing and utilization of these underutilized fruits and vegetables (Pareek, 1996).

Thus, product development and diversification of value added products have become very important for underutilized fruit production. The country is successful in evolving appropriate processing technologies for the profitable utilization and value addition in these fruits. As a result products like jam, jelly, preserve, beverages, pickle, dehydrated fruits, and vegetables have been developed and they are having good commercial potential as well as solving nutritional deficiency problems in tribal areas (Goyal and Sharma, 2009). The importance of these lesser known fruits is increasing day by day because people realized the importance of new useful terms such as caloric sweetness, insecticide compounds, and medicinal value. Most of the underutilized fruits are rich source of vitamins (ascorbic acid, thiamine, niacin, pyridoxine, and folacin), minerals, fat, protein, and dietary fiber (Gopalan et al., 1989).

#### **USE OF UNDERUTILIZED FRUITS FOR NUTRITIONAL SECURITY**

Specific nutrient deficiency, malnutrition, and under weight of children are significant challenge in tribal areas of Rajasthan. The intake of nutrients in daily diet is far from satisfactory and largely less than 50% RDA is consumed by over 70% of Indian population (Anonymous, 2002). Vitamin A, iron, and zinc deficiency when combined constitute the second largest risk factor in the global burden of diseases; 330,000 child deaths are precipitated every year in India due to VAD; 22,000 people, mainly pregnant women, die every year in India from severe anemia; 6.6 million children are born mentally impaired every year in India due to iodine deficiency; intellectual capacity is reduced by 15% across India due to iodine deficiency; and 200,000 babies are born every year with neural tube defects in India due to folic acid deficiency (Prakash and Lahariya, 2010). It increases the risk of premature delivery and low birth weight. Maximum children of tribals are suffering from IDA, retarded growth, impaired cognitive performance, and reduced physical activity. Nutrient deficiency also accelerates the mortality and morbidity rate in women. Fruits, nuts, and vegetables play a significant role in tribal population nutrition, especially as sources of vitamins {ascorbic acid (C), carotenoids (A), thiamine (B<sub>1</sub>), riboflavin (B<sub>2</sub>), niacin (B<sub>3</sub>), pyridoxine (B<sub>6</sub>), and folacin}, minerals, fat, protein, and dietary fiber (Quebedeaux and Bliss, 1988; Quebedeaux and Eisa, 1990; Craig and Beck, 1999; Wargovich, 2000). Nuts are a good source of essential fatty acids, fiber, vitamin E, and minerals. Other important nutrients supplied by fruits and vegetables include riboflavin (B<sub>2</sub>), zinc, calcium, potassium, and phosphorus (Kader et al., 2005). In some of the tribal-area vegetables, fruits and *aloe* just grow wild on barren land which are available free of cost to provide food and nutrition security. *Aloe* gel is reported to be rich in amino acids, minerals, vitamins, enzymes, proteins, polysaccharides, and biological stimulants

(Hart et al., 1989). Most of the tribal food resource is available in plenty during a particular season but all have not been utilized to desired extent due to many reasons (Anonymous, 2010). Thus, people residing in tribal areas hardly get considerable advantage from the abundantly available resources. The solution of the problem lies only in evolving the techniques of value addition, providing market, and educating the tribals about nutritional quality of underutilized commodities. Processing and value addition of tribal fruits and vegetables into more useful, digestive, tasteful, and convenient products ultimately improves the economic value of underutilized commodities and develop nutritional security of the tribals.

### Sources of Protein

Proteins are the important constituent of tissues and cells of the body. They form the important components of muscle and other tissues and vital body fluids like blood. The proteins in the form of enzymes and hormones are concerned with a wide range of vital metabolic processes in the body. Proteins supply the body building material and make good the loss that occurs due to wear and tear (Gopalan et al., 1994). Proteins, as antibodies, help the body to fight against infections. Thus, proteins are one of the most important nutrients required by the body and should be supplied in adequate (60 g for male and 50 g for female) amount in diet (Gopalan et al., 2004). Protein deficiency is wide spread in the poor and tribal area population of Rajasthan (Anonymous, 2010). Protein deficiency leads to disorders like protein energy malnutrition, kwashiorkor, etc. (Reddy, 1991). Following underutilized fruits are rich source of protein.

### Sources of Fat

Fat are an important component of diet and serves a number of functions in the body. Fat is a concentrated source of energy and it supplies per unit energy more than twice the energy furnished by either protein or carbohydrate. It also imparts palatability to a diet and retards stomach-emptying time. The essential fatty acid requirement has been placed at 3–6% of total energy intake depending on the age and physiological state

**Table 2** Fat content in some underutilized fruits

S. no.	Common name	Botanical name	Fat content (g/100 g pulp)
1	Kachri	<i>Cucumis callosus</i>	1.28
2	Mahua	<i>Madhuca indica</i>	1.60
3	Walnut	<i>Juglans regia</i>	64.5
4	Rayan	<i>Manilkara hexandra</i>	2.40
5	Wood apple	<i>Feronia limonia</i>	3.70
6	Ker	<i>Capparis decidua</i>	2.00
7	Phog	<i>Calligonum polygonoides L.</i>	11.81
8	Banyan tree	<i>Ficus religiosa</i>	2.0

Source: Gopalan et al. (2004).

(Gopalan et al., 1994). During growth, pregnancy, and lactation, essential fatty acid requirements are relatively higher. To obtain this level of essential fatty acid in the diet, the visible fat intake should be 15–25 g/day in terms of oil content of fruits and other food products. Fat is a major nutritional concern in poor societies, especially in lower income rural tribals. Fat deficiency in body causes pyronoderma (toad skin), weakness, and weight loss (Gopalan et al., 2004). Following underutilized fruits are rich sources of fat.

### Source of Carbohydrates

Carbohydrates are a class of energy yielding substances which include starch, glucose, cane sugar, sugar, etc. Starch is a complex carbohydrate made up of glucose units. Glucose derived from starch and other sugars present in the diet is the main source of energy in the body. Carbohydrates derived from different underutilized fruits form chief source of energy in Indian diets especially in tribal areas. Generally, energy requirement depends on age and nature of work (Gopalan et al., 1994). Carbohydrate deficiency in body causes weakness, weight loss, and reduced physical activity. Following underutilized fruits are rich source of carbohydrate.

**Table 3** Carbohydrate content in some underutilized fruits

S. no.	Common name	Botanical name	Carbohydrate content (g/100 g pulp)
1	Bael	<i>Aegle marmelos</i>	31.8
2	Mahua	<i>Madhuca indica</i>	22.7
3	Sitaphal	<i>Annona squamosa</i>	23.5
4	Rayan	<i>Manilkara hexandra</i>	27.7
5	Tamarind	<i>Tamarindus indica</i>	67.4
6	Ker	<i>Capparis deciduas Edgew</i>	18.2
7	Phog	<i>Calligonum polygonoides L.</i>	57.31
8	Date palm	<i>Phoenix sylvestris Roxb.</i>	70.0
9	Timra	<i>Diasporas melonoxylon</i>	27.00
10	Khejri pods	<i>Prosopis cineraria</i>	44.15
11	Snappmelon	<i>Calligonum polygonoides L.</i>	15.60

Source: Gopalan et al. (2004).

**Table 1** Protein content in some underutilized fruits

S. no.	Common name	Botanical name	Protein content (mg/100 g pulp)
1	Cudappach almond	<i>Buchanania sp.</i>	21.60
2	Jawa almond	<i>Canarium indicum lanzan</i>	19.60
3	Walnut	<i>Juglans regia</i>	13.70–18.20
4	Bael	<i>Agle marmelos</i>	1.80
5	Wood apple	<i>Feronia limonia</i>	7.10
6	Ker	<i>Capparis decidua</i>	4.21
7	Khimp	<i>Leptadenia pvrtechnica</i>	3.13
8	Khejri pods	<i>Prosopis cineraria</i>	5.10
9	Phog	<i>Calligonum polygonoides</i>	6.05

Source: Gopalan et al. (2004).

**Table 4** Energy content in some underutilized fruits

S. no.	Common name	Botanical name	Energy content (Cal./100 g pulp)
1	Bael	<i>Aegle marmalos</i>	137
2	Mahua	<i>Madhuca indica</i>	112
3	Sitaphal	<i>Annona squamosa</i>	104
4	Rayan	<i>Manilkara hexandra</i>	134
5	Tamarind	<i>Tamarindus indica</i>	284
6	Ker	<i>Capparis deciduas</i> Edgew	107
7	Phog	<i>Calligonum polygonoides</i> L.	360
8	Date palm	<i>Phoenix sylvestris</i> Roxb.	317
9	Timru	<i>Diasporas melonoxylon</i>	112
10	Khejri pods	<i>Prosopis cineraria</i>	82
11	Khimp	<i>Leptadenia pyrotechnica</i>	68
12	Kaith	<i>Feronia limonia</i>	134
13	Banyan tree	<i>Ficus religiosa</i>	110

Source: Gopalan et al. (2004).

### Sources of Energy

Energy is essential for rest, activity, and growth. It is well known that even when body is at rest, it expends certain amount of energy for essential functions such as respiration, blood circulation, digestion, absorption and excretion, maintenance of body temperature, etc. The amount of energy thus expended when the body is at complete rest (both mentally and physically) is termed as Basal Metabolism or Resting Metabolism. Some of the factors affecting Basal Metabolic Rate are- age, height, weight, and state of nutrition of the individual (Gopalan et al., 2004). The three components of foods, which provide this energy, are carbohydrates, fat, and protein. Proteins normally supply 10–12% of energy in most diets; energy that carbohydrate and fat contribute may vary from diet to diet. It is desirable that the energy from fat should not exceed 30% and rest may be derived from carbohydrate (60%). However, in diets of tribal/poor population in Rajasthan, 9–10% of energy is provided by protein, more than 80% of energy comes from carbohydrates. Raika community adult suffered from chronic energy deficiency (44.1%) was reported by Singh et al. (2009). The daily diet of an adult doing moderate work should provide at least 2875 Kcal for male and 2225 Kcal for female (Gopalan et al., 2004). In adults, Body Mass Index (BMI) is used to assess the chronic energy deficiency (51.2% in males and 37.0% in female) using cut-off values of WHO classification (WHO, 2000). Energy deficiency in body causes weakness, weight loss, marasmus, and reduced physical activity. Following underutilized fruits are rich source of energy.

### Source of Vitamins

Vitamins are organic substances present in small amount in many foods. They are required for carrying out many vital functions of the body and many of them are involved in the utilization of the major nutrients like proteins, fat, and carbohydrates. Although they are needed in small amounts, they are essential for health and well being of the body. Vitamins can be broadly classified as water soluble and fat-soluble vitamins. B-complex

vitamins and ascorbic acid belong to the former group while vitamin A, D, E, and K are the fat-soluble vitamins.

### $\beta$ -Carotene (Vitamin A)

A well-understood function of carotene is in the visual process. Vitamin A is necessary for clear vision in dim light. Lack of vitamin A thus leads to night blindness. Another function of vitamin A is to maintain the integrity of epithelial tissues (Reddy, 1972). The requirement of vitamin A is greater during pregnancy, lactation, and during growth (Gopalan et al., 1994). For example, in the absence of adequate vitamin A intake, the outer lining of the eyeball loses its usual moist white appearance and becomes dry and wrinkled. Redness and inflammation of the eye and gradual loss of vision may follow. All these symptoms are dominant in tribal population (Anonymous, 2010). Singh et al. (2009) reported that the Raika community of western Rajasthan suffered from chronic VAD (3.4%). Thus, vitamin A is one of the most important nutrients required by the body and should be supplied in adequate (600  $\mu$ g/day) amounts in diet. About 50 g of the common leafy vegetables like amaranth will provide adequate  $\beta$ -carotene to meet the vitamin A requirement of an adult. The rich source of  $\beta$ -carotene is green leafy vegetables, spinach, amaranths, coriander, drumstick leaves, curry leaves, mint, radish leaves, etc. Ripe yellow fruits such as mangoes, papaya, jackfruit, mahua, phalsa, rayan, and tree tomato are also rich source of vitamin A (Sen, 2003).

### Source of Thiamine (Vitamin B<sub>1</sub>)

Vitamin B<sub>1</sub> or thiamine is an important member of the B-group of vitamins. Prolonged deficiency of thiamine in the diet is one of the main factors leading to the disease beri-beri, dry, and wet (Gopalan et al., 1994; Bamji et al., 2004). Thiamine is concerned in the proper utilization of carbohydrates in the body and in the absence of adequate amounts of thiamine full utilization of sugars and starches for meeting the energy needs is adversely affected. Thiamine requirement of an individual is 1.4 mg/day for adult male and 1.1 mg/day for adult female (Gopalan et al., 2004). Following underutilized fruits are rich sources of thiamine.

**Table 5** Vitamin "A" content in some underutilized fruits

S no.	Common name	Botanical name	Vitamin "A" content (IU)
1	Jack fruit	<i>Artocarpus heterophyllus</i> Lam	175–540
2	Persimmon	<i>Dispyros kaki</i> L.K.	2000–2710
3	Tree Tomato	<i>Cyphomandra balance</i> Cav.	150–540
4	Kumquat	<i>Fortunella</i> spp.	2530
5	Drumstick	<i>Moringa olifera</i> Lam	184–190
6	Surinam cherry	<i>Eugenia uniflora</i>	1200–2000
7	Mahua	<i>Madhuca indica</i>	307 $\mu$ g/100 g pulp
8	Rayan	<i>Manilkara hexandra</i>	495 $\mu$ g/100 g pulp
9	Fig	<i>Ficus carica</i> L.	162 $\mu$ g/100 g pulp
10	Phalsa	<i>Grewia subinaequalis</i> D.C.	419 $\mu$ g/100 g pulp

Source: Gopalan et al. (2004).

**Table 6** Vitamin "B<sub>1</sub>" content in some underutilized fruits

S. no.	Common name	Botanical name	Vitamin "B <sub>1</sub> " content (mg/100 g pulp)
1	Rayan	<i>Manilkara hexandra</i>	0.13
2	Bael	<i>Aegle marmalos</i>	0.07
3	Sitaphal	<i>Annona squamosa</i>	0.07

Source: Gopalan et al. (2004).

#### Source of Riboflavin (Citamin B<sub>2</sub>)

Riboflavin as a part of coenzyme is essential for several oxidation processes inside the cell and is concerned with energy and protein metabolism. Some of the clinical symptoms attributed to inadequate intake of this vitamin in the diet are the soreness of tongue (glossitis), cracking at the angles of the mouth (angular stomatitis), redness of the eye and burning sensation in the eyes, and scaliness of the skin in the region between the nose and angles of the lips (seborrheic dermatitis) (Gopalan et al., 1994; Bamji et al., 2004). Scrotal dermatitis can also be a result of riboflavin deficiency. Riboflavin is the most limiting of all B-vitamins in cereal-based diets of the tribals. It is rather difficult to ensure adequate supply of this vitamin in a predominantly vegetarian diet. The daily safe requirement of this vitamin ranges from 0.7 to 2.2 mg/day depending upon age, physiological status, and level of activity (Gopalan et al., 2004). There is good evidence that tribal/poor Indian diets containing following fruits are generally sufficient in riboflavin. Bael is the richest source of riboflavin (Sen, 2003).

#### Source of Nicotinic Acid (Vitamin B<sub>3</sub>)

Nicotinic acid is a vitamin intimately connected with several metabolic reactions. It takes part as a component of coenzyme in oxidative reactions and is concerned with metabolism of carbohydrate, fats, and proteins (Gopalan et al., 1994; Bamji et al., 2004). This vitamin can be formed in the body from the amino acid tryptophan, which is present in all dietary proteins. Part of the dietary tryptophan is converted into niacin. The safe level of this vitamin has been estimated as 6.6 mg niacin equivalents per 1000 kcal. The daily requirement of this vitamin varies from 8–26 mg niacin equivalents for various physiological activity groups (Gopalan et al., 2004). Severe deficiency of nicotinic acid in the diet causes disease pellagra. Pellagra in tribal areas is seen among the poor who mostly consume maize-based diet without much protective foods, because maize is a poor source

**Table 7** Vitamin "B<sub>2</sub>" content in some underutilized fruits

S. no.	Common name	Botanical name	Vitamin "B <sub>2</sub> " content (mg/100 g pulp)
1	Mulberry	<i>Morus alba</i>	0.13
2	Wood apple	<i>Feronia limonia</i>	0.17
3	Sitaphal	<i>Annona squamosa</i>	0.17
4	Bael	<i>Aegle marmalos</i>	1.19

Source: Gopalan et al. (2004).

**Table 8** Vitamin "B<sub>3</sub>" content in some underutilized fruits

S. no.	Common name	Botanical name	Vitamin "B <sub>3</sub> " content (mg/100 g pulp)
1	Mulberry	<i>Morus alba</i>	0.50
2	Wood apple	<i>Feronia limonia</i>	0.80
3	Fig	<i>Ficus carica L.</i>	0.60
4	Rayan	<i>Manilkara hexandra</i>	0.70
5	Ber	<i>Ziziphus mauritiana</i>	0.70
6	Bael	<i>Aegle marmalos</i>	1.10

Source: Gopalan et al. (2004).

of both nicotinic acid and tryptophan. Some underutilized fruits are effective in preventing pellagra because they are rich in tryptophan and nicotinic acid.

#### Source of Ascorbic Acid (Vitamin C)

Vitamin C deficiency causes scurvy characterized by weakness, bleeding gums, and defective bone growth (Gopalan et al., 1994; Bamji et al., 2004). Ascorbic acid occurs widely in plant foods particularly in underutilized fresh fruit and vegetables, especially in green varieties. The human requirement of this vitamin is placed at about 600 µg/day. Aonla is one of the richest natural sources of the vitamin C (Sen, 2003).

#### Source of Minerals

A large number of minerals and trace metals are present in the body. Some of these form part of body structural component and some others act as catalytic agents in many body reactions. Bones and skeleton are made up of mainly calcium, magnesium, and phosphorus, and iron is a component of blood. Minerals like zinc, molybdenum, copper, manganese, and magnesium are either structural part or activate a large number of enzyme systems. Iodine is a part of hormone, thyroxine. Sodium, potassium is important elements present in fluids within and outside the cells and along with ions like chloride, bicarbonate, and

**Table 9** Vitamin "C" content in some underutilized fruits

S. no.	Common name	Botanical name of fruit	Vitamin "C" content (mg/100 g pulp)
1	Kiwi fruit	<i>Actinidia chinensis</i>	300
2	Sitaphal	<i>Annona squamosa</i>	42
3	Custard apple	<i>Annona reticulata</i>	41–43
4	Aonla	<i>Emblica officinalis</i>	500–625
5	Ber	<i>Ziziphus mauritiana</i>	39–166
6	Surinam cherry	<i>Eugenia uniflora</i>	25–44
7	Kumquat	<i>Fortunella spp.</i>	52–151
8	Barbados cherry	<i>Malpighia glabra</i>	1500–5600
9	Passion fruit	<i>Passiflora edulis</i>	35–50
10	Manila tamarind	<i>Pithecellobium dulce</i>	138
11	Strawberry guava	<i>Psidium cattleianum</i>	25–50
12	Chinese jujube	<i>Ziziphus jujuba</i>	188–544
13	Aloe	<i>Aloe vera</i>	53
14	Ker	<i>Capparis deciduas Edgew</i>	50

Source: Gopalan et al. (2004).

**Table 10** Mineral content in some underutilized fruits

S. no.	Common name	Botanical name	Minerals content (mg/100 g fruit pulp)			
			Minerals (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)
1	Aonla	<i>Emblica officinalis</i>	0.50	50	20	1.2
2	Bael	<i>Aegle marmalos</i>	1.70	85	50	0.7
3	Fig	<i>Ficus carica L.</i>	0.60	80	30	1.0
4	Mulberry	<i>Morus alba</i>	0.60	70	30	2.3
5	Phalsa	<i>Grewia subinaequalis D.C.</i>	1.10	129	39	3.1
6	Pomegranate	<i>Punica granatum L.</i>	0.70	10	70	1.79
7	Sitaphal	<i>Annona squamosa</i>	3.10	17	47	4.31
8	Wood apple	<i>Feronia limonia</i>	5.00	130	110	0.48
9	Tamarind	<i>Tamarindus indica</i>	5.60	170	110	17
10	Dates (dry)	<i>Phoenix dactylifera</i>	2.1	120	50	7.3
11	Clusterbean	<i>Cymopsis tegratonolobus L.</i>	–	130	57	1.08
12	Khimp	<i>Leptadenia pyrotechnica</i>	–	156	317	3.18
13	Phog	<i>Calligonum ploygonoides L.</i>	–	211	427	3.52

Source: Gopalan et al. (2004).

carbonate keep water and acid base balance. On an average, man excretes daily 20–30 g of mineral salts consisting of Na, K, Mg, Ca, Chloride, sulphate, and phosphates and this must be made good by an adequate intake of these mineral salts through our food (Gopalan et al., 1994). A study on underprivileged children of five years of age in tribal areas of Rajasthan exposed that maximum children are suffering from minerals deficiency (Anonymous, 2010). Mineral deficiency caused several physiological disorders in human body. The key factors responsible for mineral deficiency in tribals include improper dietary habits, elevated mineral demand, socioeconomic, and disease status of the individuals (Gopalan et al., 2004). It is well documented that the mineral deficiency reduces working capacity, and increases morbidity due to infections and greater risk of death associated with pregnancy and childbirth.

### Calcium (Ca)

Calcium is an essential element required for several life processes. As the structural component calcium is required for the

formation and maintenance of skeleton and teeth. It is also required for a number of other essential processes. It is required for normal contraction of muscles, to make limbs move, contraction of heart for its normal functioning, nervous activity, and blood clotting. The latter functions are carried out by ionized calcium present in the cells (Gopalan et al., 1994). Children need relatively more calcium than adults to meet the requirements of growing bones. Calcium requirements are also increased during pregnancy to meet the needs of growing fetus and during lactation to compensate for Ca secreted in breast milk. If the mother's diet during this period is deficient in Ca, the Ca present in mother's bones will be depleted and her bones become prone to fractures. Limited food availability, inadequate access to health care, poor environmental sanitation, high reproduction, and personal hygiene are socioeconomic factors contributing to Ca deficiency. Calcium deficiency is more prevalent in population groups that live in tribal area of Rajasthan. The population groups most vulnerable to developing calcium deficiency are infants, children, and women of reproductive age. Calcium deficiency causes rickets in children and osteomalacia

**Table 11** Comparison of the nutritive value of utilized and underutilized fruits

S. no.	Nutrients	Utilized fruits (100 g edible portion of fruits)							Underutilized fruits (100 g edible portion of fruits)						
		Apple	Orange	Guava	Mango	Banana	Papaya	Grape	Phalsa	Bael	Rayan	Timru	Sitaphal	Kair	Tamarind
1	Protein (g)	0.2	0.7	0.9	0.6	1.2	0.6	0.5	1.3	1.8	0.5	–	1.6	4.24	3.1
2	Fat (g)	0.5	0.2	0.3	0.4	0.3	0.1	0.3	0.9	0.3	2.4	–	0.4	2.00	0.1
3	CHO (g)	13.4	10.9	11.2	16.9	27.2	7.2	16.5	14.7	31.8	27.7	26.8	23.5	18.2	67.4
4	Energy (Cal.)	59.0	48.0	51.0	74.0	116.0	32.0	71	72	137	134	112	104	107	283
5	Ascorbic acid (mg)	1.0	30.0	212	16.0	7.0	57.0	1	22	8	16	1	37	50	–
6	Carotenes ( $\mu$ g)	–	1104	–	2743	78	666	–	419	55	495	361	–	–	–
7	Thiamin (mg)	–	–	0.03	0.08	0.05	0.04	–	–	0.13	0.07	–	0.07	–	–
8	Riboflavin (mg)	–	–	0.03	0.09	0.08	0.25	–	–	0.03	0.08	–	0.17	–	–
9	Niacin (mg)	–	–	0.4	0.9	0.5	0.2	–	0.3	1.1	0.7	–	1.3	–	–
10	Minerals (g)	0.3	0.3	0.7	0.4	0.8	0.5	0.6	1.1	1.7	0.8	0.8	0.9	–	2.9
11	Calcium (mg)	10.0	26	10.0	14.0	17.0	17.0	20	129	85	83	60	17	–	170
12	Phosphorus (mg)	14.0	20	28.0	16.0	36.0	13.0	30	39	50	17	20	47	–	110
13	Iron (mg)	0.66	0.32	0.27	1.3	0.36	0.5	0.52	3.1	0.6	0.9	0.5	4.31	0.76	17.0
14	Fiber (g)	1.0	0.30	5.20	0.7	0.4	0.8	2.9	1.2	2.9	–	0.8	3.1	4.24	5.6

Source: Gopalan et al. (2004), Goyal and Sharma (2009), Pareek and Sharma (1993), and Pareek and Sharma (1995b)

**Table 12** Therapeutic uses of the underutilized fruits and vegetables

Common name	Botanical name	Therapeutic use
Aonla	<i>Embllica officinalis</i>	Hemorrhage, diarrhea, dysentery, anemia, cough
Bael	<i>Aegle marmalos</i>	Appetizer, stomachic, cooling, restore vitality
Ker	<i>Capparis deciduas</i> Edgew	Biliousness, asthma, inflammations, fever, laxative, cough, cure stomach pain, vomiting, arthritis, diabetes, and hypertension
Mahua	<i>Madhuca indica</i>	Cough, cold, bronchitis
Kaith	<i>Feronia limonia</i>	Stomachic, stimulant
Jamun	<i>Syzygium cumini</i>	Stomachic, anemia, improves hemoglobin in blood, diabetes
Tamarind	<i>Tamarindus indica</i>	Useful in heart care and against stone formation in urinary system
Lasoda	<i>Cordia dichotoma</i>	Anticlimactic, diuretic, expectorant
Karonda	<i>Carissa carandas</i>	Antiscorbutic, anemia
Phalsa	<i>Grewia subinaequalis</i> D.C.	Blood purification, anemia
Aloe	<i>Aloe barbedensis</i> Mill	Antioxidant, bactericidal, fungicidal, purgative, controls arthritis, diabetes, and cholesterol level
Ber	<i>Ziziphus nummularia</i>	Helps in blood purification and improves digestion
Clusterbean	<i>Cyamopsis tetragolobus</i> L	Control constipation, anorexia, diabetes, arthritis, colic pain, hair fall, and body pain
Kachri	<i>Cucumis callosus</i>	Exert cooling effect, improve appetite, easy bowl movement, relives stomach pain, vomiting, and constipation
Khimp	<i>Leptadenia pyrotechnica</i> Forsk.	Cures constipation, arthritis and good for health
Tarbu	<i>Citrullus lanatus</i>	Relieves constipation and diarrhea, cardiac, and kidney troubles
Khejri	<i>Prosopis cineraria</i>	Help in blood purification, cures skin disease, respiratory problem and piles, cure ringworm infection, dyspepsia, and fevers.
Phog	<i>Calligonum polygonoides</i>	Exert cooling effect and good health (Choudhary and Goyal, 2003)
Snap melon	<i>Cucumis melo</i> var Linn. <i>momordica</i>	Exert cooling effect, improve appetite, and relieve constipation (Pareek et al., 1999)

Source: Goyal and Sharma (2009), Pareek et al. (1999), Sen (2004), Pareek and Samadia (1998), and Saroj (2004).

in adults (Gopalan et al., 2004). Calcium requirement for an adult male and growing child is between 400 and 600 mg/day. In case of pregnant and lactating mothers, requirement is more, i.e., (1000 mg/day) calcium.

### Phosphorus (P)

Utilization of calcium is closely linked with that of phosphorus, since most of the calcium in the body is deposited as calcium phosphate in the bones and teeth. Phosphorus is also a component of nucleic acids and as phosphate esters plays an important part in the cellular metabolism of other nutrients like carbohydrate, fat, etc. (Gopalan et al., 1994). It is usually considered that about a gram of phosphorus should be supplied in the diet. This amount of phosphorus is easily obtained even from a poor vegetarian (cereal-based) diet and phosphorus deficiency is rarely seen in tribal area of Rajasthan.

### Iron (Fe)

Iron is essential for the formation of hemoglobin of red cells of blood and plays an important role in the transport of oxygen. Tissues also require iron for various oxidation-reduction processes and some of the body reactions. Most of the iron in the body is reutilized and some of the body iron is also stored in liver and spleen (Gopalan et al., 2004). Iron deficiency has earned distinction as the most common nutritional deficiency in the tribals that affects more than 50% of the tribal population (Anonymous, 2010). Singh et al. (2009) revealed that Raika adults suffered from chronic energy deficiency (44.1%),

vitamin A and B complex deficiencies (3.4% and 2.4%) along with anemia (87.7%). Iron deficiency often leads to anemia, defined as having a blood hemoglobin level below standard, which is usually the result of insufficient dietary in-take of iron, poor utilization of iron from ingested food, or a combination of the two. The incidence of IDA is high among infants, teenagers, and women of childbearing age in tribal areas. Well-documented consequences of anemia include diminished learning ability, reduced work capacity, and increased morbidity from infections and greater risk of death associated with pregnancy and childbirth (Edgerton et al., 1979). Infant born to anemic mothers are more predisposed to low birth weight and prematurity. Some under utilized fruits are rich source of iron like; dry karonda is richest source of iron (39.1%) followed by date palm (10.6%).

In view of widespread prevalence of mineral deficiency, fortification of foods with some underutilized fruits and their products, which have sufficient amount of different minerals is desirable.

### SOURCE OF AYURVEDIC MEDICINE

It was observed that, there are serious deficiencies in the diets of our population, particularly among the tribals. As a consequence of this dietary deficiency, several nutritional deficiencies with clinical manifestation and disabilities are encountered in our country. Underutilized fruits are major source of raw material for drugs and traditional medicines. It is widely accepted that underutilized fruit produce are of explicit quality with great nutritional, medicinal, organoleptic, economic, and traditional



**Table 13** Economic value of underutilized fruits in tribal areas of Rajasthan

S. no.	Name of fruit plants	Number of plants/ha	Average yield of fruits/pl.	Average total yield (Qt./ha)	Average market rate (Rs./qt.)	Expected total income (Rs./ha)
1	Aonla	100	40	40	4	16,000
2	Bael	100	50	50	15	75,000
3	Ber	156	45	70	10	70,000
4	Ker	400	10	40	20	80,000
5	Mahua	100	70	70	30	210,000
6	Kaith	156	30	46	10	46,000
7	Jamun	100	50	50	25	125,000
8	Tamarind	100	80	80	12	96,000
9	Lasoda	100	60	60	15	90,000
10	Karonda	400	20	80	15	120,000
11	Phalsa	625	2	12	20	25,000
12	Immature mango	100	40	40	15	60,000
13	<b>Kachri</b>	—	—	50	5	25,000
14	Khimp	—	—	30	10	30,000
15	Tarbuj	—	—	100	5	50,000
16	Phog	400	12	48	5	24,000
17	Fig	100	25	25	15	37,500
18	Mulberry	277	20	55	20	110,000
19	Snapple	—	—	70	5	35,000
20	Pomegranate	400	20	80	20	160,000
21	Sitaphal	277	30	83	10	83,000
22	Rayan	100	20	20	25	50,000
23	Date palm	100	35	35	20	70,000
24	Timru	156	10	15	15	22,500
25	Khejri pods	100	25	25	20	5000

Source: Field survey in tribal areas of Rajasthan by author's during 2008 to 2011.

importance. Number of underutilized fruits is source of valuable remedies of dreaded modern ailments such as cancer, diabetes, jaundice, asthma, and nutritional deficiency. In India, fruit of aonla, bahera, and hard are the most common entering in to 219 patented drugs. Bael is also used in 60 patented drugs. Aonla is the component of most famous ayurvedic medicine chyavanprash. Ber is used in joshanda, jamun seed in diabetes, and black mulberry in docking of AIDS virus on human cell. Fruits, nuts, and vegetables in the daily diet have been strongly associated with reduced risk for some forms of cancer, heart

disease, stroke, and other chronic diseases (Quebedeaux and Bliss, 1988; Quebedeaux and Eisa, 1990; Produce for Better Health Foundation, 1999; Prior and Cao, 2000; Southon, 2000; Wargovich, 2000; Tomas-Barberan and Espin, 2001; Hyson, 2002; Goldberg, 2003). Some components of fruits and vegetables (phytochemicals) are strong antioxidants and function to modify the metabolic activation and detoxification/ disposition of carcinogens, or even influence processes that alter the course of the tumor cell (Wargovich, 2000). High consumption of tomatoes and tomato products has been linked to reduced

**Table 14** Processed products from underutilized fruits

S. no.	Name of processed products	Name of fruits
1	Jam	Jamun, karonda, aonla, jackfruit, tamarind, sitaphal, bael, ber, mulberry, wood apple, etc.
2	Jelly	Tamarind, jamun, karonda, barbados cherry, etc.
3	Preserved	Ber, aonla, bael, ker, sangari, karonda, etc.
4	Candy	Aonla, ber, karonda, datepalm, tamarind, etc.
5	Glazed fruits	Tamarind, annanas, aonla, etc.
6	Juice/beverage/squash	Tamarind, bael, jamun, karonda, phalsa, ber, aonla, pomegranate, mulberry, wood apple, etc.
7	Wine	Mahua, wild apricot, datepalm, karonda, ber, Indian fig, etc.
8	Chutney	Karonda, tamarind, ker, aonla, wood apple, etc.
9	Sauce	Karonda, tamarind, wood apple, pomegranate
10	Pickle	Aonla, karonda, ker, lasoda, sangari, kachri, khimp, immature mango, ber, tamarind, etc.
11	Dehydration	Bael, jackfruit, karonda, ker, phalsa, ber, kachari, sangari, khimp, mulberry, date palm, lasoda, tamarind, aonla, custard apple, etc.
12	Frozen puree	Tamarind, bael, karonda, ker, phalsa, tamarind, custard apple, etc.
13	Canning	Ber, aonla, jamun, ker, etc.
14	Confectionary	Aonla, tamarind, immature mango, etc.

Source: Goyal and Sharma (2009), Singh et al. (2008), Sen (2003), and Pareek and Sharma (1993).



**Figure 1** Malnourished children of Aburoad tribal area of Sirohi district Rajasthan. (Color figure available online.)

carcinogenesis, particularly prostate cancer, and has been thought to the presence of lycopene (Giovannucci, 2002; Boileau et al., 2003). The stem and bark of *Khejri* is used for curing boils, leprosy, dysentery, asthma, piles, and tumors (Saroj, 2004). Daily use of *aloe* juice shows significant improvement in glycemic control, lipid profile, and BMI of Type-2 diabetes (Deepti et al., 2007).

### SOURCE OF SUSTAINABLE INCOME

Underutilized fruits are the source of sustainable income in tribal areas. Number of plant produce (root, leaves, fruits, gum, etc.) has high economic value in market. Many economically useful fruits, vegetables, and medicinal viable plants like, anola, ber, custard apple, jamun, tamarind, bael, ker (*Capparis apphyulla*), lasoda (*Cordia mixa*), sangari (*Prosopis cineraria*), karonda, dates, tumba (*Citrullus colocynthis*), kumtia (*Acacia senegal*), kachari (*Cucumis melo*), timru, etc. are either propagated or naturally available in the tribal areas of Rajasthan (Anonymous, 2011). The tribal (women and children) and weaker sections of the society collects these fruits and useful part of the plants from the widely scattered trees and bushes in the region from time to time during the season. A part of their collection is retained for their own consumption as raw or in dried form and surplus is sold to the local traders and road side (Jain, 2003; Anonymous, 2011). The market of underutilized fruit in turn is influenced by a number of factors like

consumer preference, process ability, value addition, export, domestic consumption, foreign demand which again is based on our knowledge about the health promoting qualities and nutritional value of the crops (Chundawat, 2003). The global forum on Agriculture Research (GFAR) in 1999 also emphasized the role of underutilized species in raising income of the rural poor.

### Value Addition of Underutilized Fruits

Accurate statistics with regard to quantity produced and processed is unavailable for underutilized fruits because a sizeable quantity of the fruits produced is self-consumed, exchanged or sold locally. The majorities of fruit species in Rajasthan are not cultivated on a large-scale or commercial basis, but rather are grown in the wild or in home gardens or field boundaries. Normally, the fruits are collected from the wild forest and sold fresh on a seasonal basis, with limited processing (Azam-Ali,



**Figure 2** Tribal's local market for selling fruits and vegetables. (Color figure available online.)

**Table 15** Quantity of amla, tamarind, and kokum produced and processed in India

Species	Produced (tons)	Processed (tons)	Reference
Amla	250,000	225,000	Nagarajan, 2005
Tamarind	300,000	280,000	Anbu, 2005
Kokum	10,200	9,000	Sawant, 2005



**Figure 3** Seed of Kumtia (*Acacia senegal*) high proteinaceous tribal area legume. (Color figure available online.)

2003). The volume processing is very high for all the species, as it refers to primary processing, which mainly involves the removal of pulp and drying. The socioeconomic status of rural families can be improved through value addition of underutilized fruits (Anonymous, 2011). It can facilitate optimum utilization of available resources and can have great future in waste land fruit production. *Pachutta* is most common processed product of underutilized fruits (Pareek and Samadia, 1998). The establishment of agro-processing industries in rural and tribal areas is necessary not only to meet the ever increasing demand for processed products but also to enhance real farm income in future (Anonymous, 2011). Value addition will also generate required employment potential for tribal workers. The technique of value addition, involves processing of horticultural raw material to create edible or usable forms, easily transportable forms, improves storage and shelf life of the products. Processing of arid fruits and vegetables into more useful and convenient products, ultimately improves the economic value of any product, which is the most vital component of value addition (Goyal and Sharma, 2006). Ber pulp is used for making drinks (Kiradoo and Goyal, 2005), Fresh ker fruits used as vegetable and pickle, immature fruits are also dried for subsequent use as vegetable in off season (Sen, 2003).

## CONCLUSIONS

In the present socioeconomic scenario, when India is facing the problems of hidden hunger, nutrient and micronutrient deficiencies, poverty, and unemployment. The wise and proper utilization of underutilized horticultural crops can prove to be a promising solution after realizing their health and employment potential. The underutilized crops can be a rich and easily available source of major and minor nutrients in sufficient amounts to prevent and cure deficiency disorders. They are the source of ayurvedic medicine because of having therapeutic properties. It is also established fact that seasonal, locally available, and cheap fruits and vegetables can also keep the population healthy and nutritionally secure rather than costly off season ones. They can

fetch self-employment opportunities through marketing of raw fruits and vegetables. Along with it, employment can be generated by value added product preparation through processing. Hence, it can be concluded that exploitation of underutilized horticultural crops can provide a way to nutrient and economic security of tribals. Also, tribals can earn their livelihood through use of underutilized fruit crops.

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