Fruits and vegetables by virtue of their colours, fragrance and taste impart variety of food. In addition, they are important source of many minerals, vitamins and some vegetables contribute significant proportion of carbohydrate, proteins and enzyme, which are essential in the human diet. Fruit and vegetable crops as Mohideen (1991) has pointed out assure the farmers a steady flow of income while their exports fetch the exchequer a sizeable foreign exchange. They also provide ample scope for employment generation for the rural people. India is the basket of fruit and vegetable in the world. India being a home of wide variety of fruits and vegetables, and hold a unique position in production figures among other countries. Endowed with diverse agro-climatic conditions such as tropical, subtropical, arid and temperate, India holds a unique position for growing wide range of fruits and vegetables. India with its diverse soil and climate, comprising several agro-ecological regions provides many opportunities to grow a variety of horticultural crops. These crops form a significant part of the total agricultural produce in the country comprising of fruits, vegetables, root and tuber crops, spices, condiments, mushrooms etc. It is estimated that all the horticultural crops in India, put together cover nearly 23.69 million hectares with an annual production of 268.84 million tonnes of horticultural produce in the year 2012-13 whereas, in Arunachal Pradesh, total area under horticultural crops is 72 thousand hectares with an annual production of about 350 thousand tonnes (Anonymous, 2013).

Fruits and vegetables play unique role in developing countries like India in economic and social spheres for improving the income and nutritional status of the rural people. They are not only used for domestic consumption and processing into various products (pickles, preserved sauces, jam, jelly, squash, murrabba, etc.) but also substantial quantity exported in fresh and processed form, bringing much-needed foreign exchange for the country. Fruits and vegetables crops also provide ample scope for maintaining ecological balance and to create sustainable agriculture.
and can make an impact on the national economy of the country. Though there is a rapid expansion of area under the cultivation of fruits and vegetables crops in India, from 8.47 million hectares with a production of 87.16 million tonnes during the years 1991-92 to the current area is 16.18 million hectares with an annual production of 243.46 million tonnes during the year 2012-13 whereas in Arunachal Pradesh, total area under fruits and vegetables crops is 81.40 thousand hectares with an annual production of 218.00 thousand tonnes (Anonymous, 2008).

1.1 Fruits

India accounts for 10 percent of the world production of fruits and stands second largest producer in the world after Brazil (Singh, 2009) and also top producer in the world in mango, banana, and papaya. The largest area in India is under mango production, followed by citrus and largest production of banana followed by mango (Anonymous, 2013). The annual production of fruits is more than 81.28 million tonnes from an area of 6.98 million hectares with productivity of 11.6 MT per hectares in India. In Arunachal Pradesh total area under fruits cultivation in the year 1991-92 was 20.20 thousand hectares with a production of 47.30 thousand tonnes, which increased up to 86.90 thousand hectares with an annual production of 308.90 thousand tonnes in the year 2012-13 (Anonymous, 2013). Fruit crops play a prominent role in the economy of the country; fruits in particular contribute to national wealth, they are also important exportable commodities in many states. With its diverse soil and climatic-conditions, a large variety of fruits are grown in India, of which mango, banana, citrus, guava, grape, pineapple and apple are the major ones. Apart from these, fruits like Papaya, Sapota, Annona, Phalsa, Jackfruit, Ber, Pomegranate in tropical and sub-tropical regions and peach, pear, almond, walnut, apricot, strawberry and kiwi fruits in the temperate regions are also grown in a sizeable area.

Fruits form a complete, wholesome food for the grown up, still growing and the invalids alike, leading to healthy body and mind. It is a ready source of energy with the unique capacity to guard against many deficiency diseases. Fruits, fresh or dried have been natural staple diet of human being since ancient times, and contains minerals, vitamins, enzymes that are easily digestible. They are not only good
source as food; they are also used as medicine to heal various ailments. Fruits can supply more than one third of the total requirements of calories, vitamins and minerals to humankind. With the active participation of plant scientists it should not be difficult to meet the requirement of our needs of fruits. Therefore, more stress need to be laid on the relationship of the physiology of the plant with cultural practices.

Pummelo (*Citrus grandis* Osbeck.) is a citrus fruit, native to south-east Asia. It is found growing wildly in north-eastern states of India. It is also referred to as Chakotara in India. Pummelo fruits provide adequate nutrition with respect to vitamin C; however their role in providing other nutrients and factors of medicinal value cannot be underestimated. The peel of this fruit is also used in Chinese cooking. Chandler, a Thai cultivar and Indonesian cultivars viz., Djeroek, Deleema, Kojar are pink fleshed. In Manipur, this fruit is known as ‘Nobab’ and is used as a major source of vitamin C and this fruit holds a high place in the culture and tradition of Manipur. Many religious rituals seem incomplete without this fruit. In Tamil Nadu, it is locally called as ‘Gadarangai’. In Arunachal Pradesh and Assam states, fruits are considered as sacred and used in worship. Pummelo and allied citrus fruits are extensively grown owing to their medicinal and nutritive value to form an industry of importance. In India, pummelo with all allied citrus crops covers 1.04 million hectares area and production of 10.09 million tonnes with a productivity of 9.7 MT per hectare in the year 2012-13 whereas in Arunachal Pradesh, total area under citrus crops is 39.4 thousand hectares with an annual production of 176.71 thousand tonnes (Anonymous, 2013).

Aonla or Indian gooseberry (*Phyllanthus emblica* Linn. Syn. *Emblica officinalis* Gaertn) is an important indigenous fruit crop of tropical Asia and widely grown in tropical India belongs to the family Euphorbiaceae, subfamily Phyllanthoideae. The fruits of aonla are globular, fleshy and smooth and of striated, yellowish-green, color and they contain an obviate-obtusely triangular six- celled nut (Pandey, 2002). It is native to tropical Southeastern Asia, particularly central or Southern India (Firminger, 1947 and Morton, 1960). Naturally growing aonla has been reported from Ceylon, Cuba, China, Florida, Iran Iraq, Java, Purto Rico, and
Pakistan, (Benthal, 1946). Religious literature like “Vedas”, “Ramayan”, “Charak Sanghita”, “Sushrut Sanghita” and other ancient literatures depict the cultivation of aonla. As a good source of ascorbic acid, it is used in several medicines and also utilized either in fresh form or as a preserved one like murabba, candy, juice, pickle and chutney; fruit pulp is also used as hair conditioner and hair oil. Aonla fruits are important constituent of many Ayurvedic medicine preparations such as Chayavanprash and Triphala churan and is regarded as “one of the best rejuvenating herbs” (Majeed et al. 2009). It is astringent, cooling, refrigerant, diuretic and laxative. It is grown in an area of about 15,750 hectares with a production of around 63,000 MT in U.P. and accounts for 41.9 percent of total aonla production in India.

Papaya or Papita (Carica papaya L.) belongs to Caricaceae family is a herbaceous, quick growing plant has an erect, branchless trunk with scars from old leaf stems and crown of palmately lobed leaves with long hollow petioles. Branching may occur with age or if the apical growing point is damaged and can bear fruits for more than 20 years (Malo and Campbell, 1986), though not economical from commercial point of view. Papaya is a very wholesome fruit, and ranks it second only after to mango as a source of precursor of vitamin A (Aykroyd, 1951). Normally, the species is dioecious, but hermaphroditic forms are known, and numerous irregularities in the distribution of the sexes are common. It is only a very coarse and robust herb with leaves reaching sometimes nearly 3 feet across. It is an excellent quality fruit, rich in vitamin A and is consumed fresh when ripe, while the green fruits are grated in salads.

The fruits are rich in protein and minerals. Unripe fruit is rich source of enzyme papain. Leaves are boiled and used the water for treatment of malaria (Titanji et al., 2008) and leaf juice can raise platelet levels in blood. Papaya fruits contain 89.6 percent moisture, 0.5 percent protein, 0.1 percent fat, 9.5 percent carbohydrate, 0.01 percent Ca, 0.01 percent P, 0.4 percent iron and vitamine C 40 mg/100 g, Riboflavin 250 mg/100 g (Aykroyd, 1951). In India, papaya occupied area in the year 2012-13 was 0.13 million hectare with an annual production of 5.38 million tonnes with a productivity of 40.7 MT per hectare (Anonymous, 2013). The
major Papaya producing states are Bihar, Assam, Uttar Pradesh, Karnataka, Gujarat, Orissa, West Bengal, Maharashtra and Madhya Pradesh.

Pineapple (*Ananas cosmosus* Merr. Syn. *Ananas sativus* Schult.) is being cultivated in high rainfall and humid coastal regions of peninsular India and hilly areas of North-Eastern region. The plant is herbaceous perennial, 0.75 -1.5 meters high with a spread of 1.00 to 1.30 meter. As the stem continues to grow, it acquires at its apex a compact tuft of stiff, short leaves called the crown or top. Occasionally, the plant may bear two or more heads. The quality of delicious pineapple rests on the sugar: acid blend of the fruits, Pineapple fruit is very low in saturated fat, Cholesterol and Sodium. It is a good source of dietary fiber and vitamin C.

In India, the area under pineapple cultivation was 0.10 million hectares in the year 2013-13 with an annual production of 1.57 million tonnes and productivity 14.9 MT per ha, whereas in Arunachal Pradesh, total area under pineapple cultivation is 12.28 thousand hectares with an annual production of 67.58 thousand tonnes with a productivity of 5.5 MT per ha (Anonymous, 2013). The major Pineapple producing states are West Bengal, Assam, Meghalaya, Tripura, Manipur, Arunachal Pradesh, Kerala and Karnataka.

**1.2 Vegetables**

The efforts in increasing vegetables production will ensure better health of people, higher income and greater employment opportunity to growers and youth particularly in rural areas, diversity in income resources and sustainability in agricultural production systems. Vegetables are easily accessible and cheaper source of nutrients, vitamins, minerals and other elements essential for human being, and most of them have high medicinal value. Vegetables add variety, colour and texture in our diets (Rai et al. 2004).

India is the second largest producer of the vegetables after China contributing 13.4 percent of the world production (Singh, 2009). In india, an annual production of 162.18 million tonnes from an area of 9.20 million hectares in the year 2012-13 with a productivity of 17.3 MT per hectares, whereas in Arunachal Pradesh,
vegetables production was only 79.90 thousand tonnes from an area of 17.10 thousand hectares in the year 1991-02 which increased, vegetables production 37.6 thousand tonnes from an area 1.5 thousand hectares with a productivity of 24.7 MT per hectares in the year 2012-13 (Anonymous, 2013). In India, leading vegetables growing states are West Bengal, Uttar Pradesh, Bihar, Orissa, Tamil Nadu, Gujarat, and Maharashtra etc. We have a quantum jump in production of vegetables during the last decade. Presently, the consumption of vegetables in the country is 175g per capita per day, which is lower than the recommended dietary allowance (RDA) of 280g per capita per day. Although vegetable production has appreciably increased over the last two decades, it is yet not sufficient to meet the needs of the increasing population for achieving nutritional security.

Vegetables, besides providing nutritional security, are also major source of income especially for small and marginal farmers of Arunachal Pradesh. Newly developed short duration cultivars of vegetables crops like cabbage, tomato, potato, pea, okra etc. fit in the rice based cropping system of this state and thereby the cropping intensity can be increased many fold. Besides the vegetables, crops give more yields per unit area, more labour incentives, more remuneration, can improve the economic condition of the growers as compared to cereal crops in this state.

Potato (Solanum tuberosum L.) belongs to the family solanaceae and most widely grown vegetable in the country and occupies first position in India amongst all vegetable crops in terms of production as well as area. It contains starch, sugar, cellulose, crude fibre, pectin substances, protein, amino acids, lipids, vitamin C, minerals etc. considered useful for human health. In India, the area under potato cultivation in the year 2012-13 was 1.99 million hectares with an annual production of 45.34 million tonnes, whereas in Arunachal Pradesh, total area under potato was 4000 hectares with an annual production of 31.7 thousand tonnes (Anonymous, 2008). Utter Pradesh, is the leading potato growing state in the country followed by Bihar, West Bengal, Punjab, Karnataka and Assam.

Tomato (Solanum lycopersicum L.) belongs to the family Solanaceae and known to be protective as well as productive supplementary food because of its special nutritive value. It occupies third position in India amongst the vegetable
crops in terms of both area and production. The total annual production in the country in the year 2012-13 was 18.22 million tonnes from an area of 0.88 million hectares with a productivity of 20.7 MT per hectares, whereas in Arunachal Pradesh, total area under tomato cultivation 0.55 thousand hectares with an annual production of 14.85 thousand tones with a productivity 27.0 MT per hectares. Andhra Pradesh, Orissa, Karnataka, West Bengal, Bihar etc. are main tomato producing states (Anonymous, 2013). As it is a short duration crop and gives high yield, it is important from economics point of view and hence area under its cultivation is increasing day by day. Tomato is a rich source of minerals, vitamins organic acid, essential amino acids, Lycopene and Beta-carotene pigments and dietary fibre etc. Besides salad it is widely employed in cannery, and made into soup, sauce, ketchup, chutney, paste, puree, etc.

Okra or Bhindi (*Abelmoschus esculentus* (L.) Moench) belonging to family Malvaceae is grown from seeds, for green pods (fruits) in the tropical and sub-tropical parts of the world. Okra plant is an annual or perennial, growing up to 1-2 m tall. The leaves are 10–20 cm long and broad, palmately lobed with 5–7 lobes. In India, during 1998-99, total area under okra was 3.26 lakh hectares and total green pods’ (fruits) production was 33.80 lakh tonnes (Thamburaj and Singh, 2001).

Okra green pods (fruits) contain (per 100 g of edible portion) Moisture 89.6 g, Carbohydrates 6.4 g, protein 1.9 g, Fat 0.2 g, fibre 1.2 g, Minerals 0.7 g, Calcium 66mg, Magnesium 43 mg, Phosphorus 56 mg, Iron 1.5 mg, Sodium 6.9 mg, Potassium 103 mg, Thiamine 0.07 mg, Riboflavin 0.10 mg, Nicotinic acid 0.60 mg, Vitamin C 13mg (Aykroyd, 1963). Matured fruits and stems containing crude fiber are used in the paper industry. Okra is said to be very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Nadkarni, 1927). In India, it occupies 0.53 million hectares area with an annual production of 6.35 million tonnes with productivity of 12 MT per hectares (Anonymous, 2013). Maharashtra, Gujarat, Karnataka, Tamil Nadu, Punjab are the states for major okra cultivation.

Though some of the commercial fruits do not flourish in Arunachal Pradesh, yet some fruits like pineapple, papaya, banana, jackfruit, guava and citrus species grow well in the tropical and sub-tropical regions and a few like apple, plum, peach,
kiwi, walnut etc. in the temperate regions. Similarly, among the common vegetables tomato, potato, okra, brinjal, radish, carrot, cabbage, cauliflower, spinach, laipatta, cucumbers, knol-khol etc. are grown on commercial scale. Total production of fruits in Arunachal Pradesh was 312.2 thousand tonnes from an area of 86.9 thousand hectares with productivity of 3.6 MT per hectare during 2012-13. Regarding vegetables, the area was 1.5 thousand hectares with a production of 37.6 thousand tonnes and productivity of 27.6 MT per hectare (Anonymous, 2013). In Arunachal Pradesh orange, pineapple, banana, citrus etc. are grown in Along, Lohit, East Siang, Papumpare etc. districts and apple, kiwi, plum, walnut etc. are grown in Tawang and Bomdila districts, whereas potato, tomato, cabbage, okra, brinjal, radish, carrot, cabbage, cauliflower, spinach, laipatta, cucumbers, etc. are grown in Pashighat, Subansiri, Seppa, Papum Pare and other districts. But the total production is quite meager.

Growing population, poor crop yield and to overcome the poverty and hunger, and considering nutritive and economic importance of the fruits and vegetables a systematic study was planned with an aim to assess the physical, nutritional and yield of major cultivars grown in Papum Pare district of Arunachal Pradesh. A comparative study of the selected major local and improved cultivars was undertaken on above aspects to recommend the most suitable crops and cultivars for the state in particular and northeast region in general. The proposed study would enrich the existing knowledge on fruits and vegetables crop diversity in Arunachal Pradesh. So far there has not been any specific study to arrive at estimation of bio-chemicals of local cultivars of fruits and vegetables in the state. Therefore, the present study was undertaken to assess the physical and biochemical characteristics of selected fruits and vegetables. Thus, keeping above points in consideration the present study was carried out with the following major objectives:

- Documentation of the fruits and vegetables and their utilization.
- Determination of the biochemical characters of selected locally available fruits and vegetables for nutrient valuation.
- Estimation of production of the fruits and vegetables of Arunachal Pradesh.
Horticultural crops play an extraordinary role in the prosperity of many countries. There are many examples where the economy of a country is partly dependent on its fruit culture e.g. pineapple in Hawaii, banana in West Indies, orange in Florida State of USA etc. In these countries however, the fruit production technology is highly developed (Sadhu and Chattopadhaya, 2001). Fruits and vegetables are the only natural sources of protective food supplying all the nutrients especially minerals, vitamins and crude fibre. Vegetables on the other hand comprise a large number of plants mostly annual of which different parts like leaf, stem, flower, fruit, root etc. are eaten. They are rich in nutrients and are essential items of a balanced diet. Vegetables are called protective food as their consumption can prevent several diseases. Many vegetables are important item of commerce and thus can play a major role in the economic development (Gupta, 2004). Literature regarding the cultivars of fruits and vegetables grown in Arunachal Pradesh is quite inadequate; therefore, the observations and study made in India and abroad have also been incorporated here.

2.1 Physical Parameters

Hazarika et al. (2013) carried out a study during 2009–2010 to identify the elite pummelo genotypes among its natural population in different districts of Mizoram. During fruiting season, ripe fruits of 12 selected collections were analyzed for different physico-chemical traits, viz., significant variation observed for physical parameters, viz., individual fruit weight ranged from 393.89–903.48 g; fruit diameter 8.16–14.01 cm. Similarly, among the chemical parameters, juice content varied from 18.83–41.93 %; ascorbic acid 17.40–52.70 mg/100 g. Wide range of variation in physico-chemical parameters of pummelo collections indicated the great scope of individual plant selection based on these characters for future genetic improvement programme.
Hazarika et al. (2013a) carried out a study during 2010–2011 to identify the elite hatkora (*Citrus macroptera* Mont.) collections from different districts of Mizoram. The ripe fruits of 15 selected collections analyzed for physical parameters, *viz.*, fruit weight, diameter, length, volume, specific gravity and quality parameters, *viz.*, juice, TSS, ascorbic acid, acidity, reducing, non-reducing and total sugars. The study reveals that there is significant variation among the collections in these particular traits. Individual fruit weight ranged from 332.00–654.44 gm; fruit diameter 8.53–10.31 cm; fruit volume 283.33–584.67 cc; fruit length 5.94–8.87 cm; specific gravity 1.04–1.27 g/cc. Similarly, chemical parameters i.e. juice content varied from 16.06–27.13 %, ascorbic acid 36.47–49.77 mg/100 ml, acidity 6.20–8.85 %, total sugars 5.31–7.33 % and sugar: acid ratio 0.63–1.18. Wide range of variation in physico-chemical parameters of hatkora collections indicated the scope for individual plant selection based on these characters.

Singh et al. (2012) conducted an experiment on young of NA-7 aonla trees to evaluate the influence of various levels of organic and inorganic nutrient on morphomatrix, productivity and quality attributes during 2007 and 2008 under hot semi-arid ecosystem at Central Horticultural Experiment Station (CIAH), Vejalpur, Panchmahals, Gujarat. The vegetative growth, yield and quality of *aonla* were influenced significantly by different sources of nutrients. Vegetative growth was recorded significantly highest in the plants treated with farm yard manure coupled with standard dose of NPK. Various treatment combinations of organic nutrient sources increased the fruit yield and quality. Maximum yield per plant (32.15 kg) recorded with the plants, which were treated with FYM plus standard does of NPK. Quality parameters like TSS, vitamin C and total phenols were influenced considerably by the application different organic sources of nutrients.

Kumar et al. (2011) studied the performance of eight cultivars of aonla (*Emblica officinalis* GAERTN.) under Coorg conditions at CHES, Chettali, Kodagu, Karnataka, where observations with respect to yield and physico-chemical properties were taken during the 2006-07 to study the proximate yield and physico-chemical properties of five year old trees of aonla cultivars namely Kanchan, NA-6, NA-7, NA-10, Krishna, Chakaiya, BSR-1 and Local (Deshi). The fruit size found NA-6
(4.20×3.52), Krishna (4.17×3.67cm), Chakaiya (3.90×3.47), Kanchan (3.87×3.38), NA-7 (3.80×3.38), NA-10 (3.78×3.32) and local Deshi (2.37×2.05) cm length and breadth, respectively. The average fruit weight observed maximum in Krishna (37.75 g), followed by NA-6 (36.95 g), Chakaiya (31.24 g), Kanchan (30.52 g), NA-10 (29.10 g), NA-7 (27.93 g), and minimum Local (6.70 g). Regarding the yield observed maximum in BSR-1 (17.56 kg/plant), NA-7 (4.80 kg/plant) and minimum in local Deshi (2.37 kg/plant). Maximum Vitamin-C content was found in BSR-1 (448.80 mg/100g) followed by local Deshi (406.56 mg/100g), NA-7 (329.56 mg/100g) and minimum in Kanchan (228.80 mg/100g).

Shukla et al. (2010) reported the performance of different commercial cultivars of aonla (*Emblica officinalis* GAERTN.) under hot arid condition viz. Krishna, Kanchan, Chakaiya, NA-6, NA-7, NA-10 and Anand-1. Observations with respect to growth parameters were taken during the month of June whereas; fruit characters were recorded at the time of harvesting in December. Maximum fruit size was observed in Krishna (3.92×4.60cm) and minimum in Kanchan (3.31×3.80cm). However, fruit weight varied from 30.16 to 48.3g depending on cultivar and it was maximum in Krishna (48.3g) and minimum in Kanchan (30.16g). Besides, there were significant variations with regards to yield, Vitamin-C, and juice content. Singh et al. (2004) made an exhaustive study on aonla (*Emblica officinalis*) cultivars and found the average fruit weight of different cultivars as NA-10, 44.84 g; NA-7, 42.90 g; NA-6, 41.40 g; Chakaiya 35.82 g and Kanchan 30.92 g. Ghosh et al. (2002) evaluated the five cultivars (i.e. Chakaiya, Kanchan, Krishna, Neelam and NA-10) of aonla fruits, cultivar NA-10 recorded highest fruit weight 34.20 g.

Sharma et al. (2011) conducted a field experiment during summer season of 2005 and 2006 to assess the effects of sources of nutrients and their levels on the performance of okra. It observed that incorporation of vermicompost 5 t ha⁻¹ resulted significantly higher fruit yield (69.2 q ha⁻¹) and protein content (1.80 percent). Whereas fruit length (10 cm), fruit diameter (1.8 cm), yield (73.8 q ha⁻¹) as well as protein content (1.85 percent), phosphorus content (0.57 percent) recorded with the fertility of level 80:60:60 kg NPK ha⁻¹. Maximum fruit yield of 86.4 q ha⁻¹ along with the combination of vermicompost 5 t and 80:60:60 kg NPK ha⁻¹.
Without fertilizer and vermicompost fruit length (4.9 cm), fruit diameter (1.1 cm), yield (41.6 q ha\(^{-1}\)) as well as protein content (12.4 percent), phosphorus content (0.31 percent).

Kumar et al. (2011a) investigated on physical parameters for 10 genetically diverse okra (*Abelmoschus esculentus* (L.) Moench) genotypes. All possible single crosses excluding reciprocals made among these parents and all 10 parents and 45 F1s were sown in a randomized block design with three replications. Observations recorded on quantitative traits showed considerable genetic variability. High heritability estimates in okra recorded for fruit width (1.58; 1.54 cm), fruit length (12.06; 12.13 cm) and weight of fruit (248.24; 230.84 g) per plant in both parents and F1 generation, respectively. Fruit width, fruit length and weight of fruits per plant are most desirable characters, which affect the yield and such characters should be taken into consideration while making selection for overall improvement. Tyagi and Khandelwal (1985) noted 12.22 and 1.49 cm length and diameter for green pods of okra respectively when the plants did not receive any treatment.

Sharma and Sharma (2013) reported that tomato is one of the most important vegetable crops and is known for its versatile uses. Mean performance of thirty different tomato genotypes evaluated. On the basis of mean performance among parent, cultivar AI-9 found the highest fruit weight (77.80 g) followed by CL-1131 (73.87 g) and FT-5 (73.22 g) and lowest in EC-174031 (30.77 g). The fruit yield among the crosses varied from 764.33 (EC-174023 x UHF-663) to 1808.23 g (AI-9 x Solan Vajr).

Shankar et al. (2012) studied on tomato crop grown using organic manures and chemical fertilizers and the effect of organic farming on nutritional profile, quality characteristics and toxic parameters. The experiment laid out in a randomized block design with fifteen treatments consisting of four organic manure treatments of vermicompost (VC), poultry manure (PM), farm yard manure (FYM), cow dung (CD) and recommended dose of chemical fertilizers, i.e., conventional farming as control. Organically and conventionally grown tomato were analysed for their nutrient composition. Application of organic manures found to be significantly
influence the nutrient content (iron, calcium, crude fibre, vitamin C) compared to conventional fertilizers application.

Thangam and Thamburaj (2008) recorded the effect of shade on growth, yield and quality of six cultivars and fourteen hybrids in tomato (*Lycopersicon esculentum* Mill.) under agro shade net (50 percent) and in open field simultaneously during consecutive summer seasons. During summer, the highest mean fruit weight recorded under shade was 59.5 g in hybrid Rashmi. The number of fruits per plant was more in open field than under shade. The yield under shade was low compared to open field. Highest yield recorded in Avinash-2, 2642.9 g; Naveen, 2303.4 g and S-41, 2129.8 g per plant in open field.

Unnithan (2008) studied physico-chemical composition of 12 pawpaws (*Carica papaya* L.) (Papaya) fruits cultivars (Co-2, Co-3, Co-4, Co-5, Coorg Honey Dew, Sunrise Solo, 9-1D, Thailand, Tainung, Pusa Dwarf, Pusa Nanha and Washington) grown in Trivandrum, Kerala, India. Pusa Nanha was superior in terms of fruit weight (1754.44 g), volume (1537.22 cm$^3$), length (27.14 cm) and fruit girth (49.72 cm). Pulp yield was highest (69.22 percent) for Tainung. Zaman *et al.* (2006) carried out a study on four cultivars of Papaya (*Carica papaya* L.) namely Bombai, Deshi, Shahi (Yellow) and Shahi (Red) for their physico-chemical composition, grown at Rajshahi, Bangladesh. The mean values of results showed (1740±0.415 g; 4.4±0.017 cm; 25.0±0.24 cm, 709.80±0.355 g; 3.8±0.002 cm; 20.0±0.22 cm, 686.40±0.358 g; 3.8±0.003 cm; 19.0±0.02 cm and 645.40±0.046 g; 3.7±0.002 cm; 20.5±0.025 cm) in Bombai, Deshi, Shahi (Yellow) and Shahi (Red) with fruit weight, fruit diameter and fruit length, respectively.

Potato cultivars are primarily distinguished based on their habit, pigmentation on the stem, structure of leaf, flower and fruit (berry) colour and tuber characters like shape, size and colour, depth of eyes and flesh colour etc. Thamburaj and Singh (2001) reported that tubers of Kufri Sinduri and Kufri Swarna are medium in size whereas, Kufri Chandramukhi and Kufri Badsaha produced larger tubers while Kufri Jyoti gives medium size of tubers.
Koul et al. (1996) studied nine cultivars of tomato. Number of fruits per plant ranged between 13.6 (Shalimar-II) and 35.3 (AC-238) during 1992 and 13.3 (Shalimar-II) and 35.6 (AC-238) during 1993. Single fruit weight during the year 1992 ranged between 27.5 and 56.3 g. Sioux recorded the maximum mean single fruits weight (56.3 g) and was at par with T-777, Shalimar-II, Pusa Sheetal, Money Maker and Solan Gola. During 1993, T-777 recorded the maximum single fruit weight (55.6 g) and was at par with Pusa Sheetal, Shalimar –II, Sioux, SL-12 and Money Maker, cultivars. AC-238 recorded the lowest single fruit weight. Pusa Ruby is an early cultivar having 20-30 fruits per plant.

Sen and Mitra (1990) reported great variation in pineapple cultivars of Giant Kew, Red Spanish, Queen, Avacaxi, Cayenne and Maipur in respect of fruit weight as 1.6–3.0, 0.9–1.8, 0.5–1.1, 1.4, 2.3 and 0.8 – 2.5 kg, respectively.

Hazarika et al. (2009) reported that aonla (Emblica officinalis) is found scattered throughout Jorhat district of Assam. The ripe fruit of 14 selected types were analyzed for physico-chemical traits like fruit weight, pulp weight, seed weight, volume, specific gravity, pulp: seed ratio, width of fruit and seed. The study reveals that there was a wide variation among its accessions. Individual fruit weight ranged from 3.24 to 10.18 g; pulp weight 2.83 to 9.41 g; seed weight 0.37 to 1.66 g; and pulp: seed ratio from 3.21 to 14.00. Wide variation in physico-chemical analysis of genotypes indicated the scope of individual plant selection based on these characters for the genetic improvement of aonla.

The specific gravity of aonla fruit was also recorded 1.10 in Chakaiya followed by 1.08 Harpharori, 1.06 Desi and 1.03 Banarasi, respectively, as noticed by Singh et al. (1987). Teaotia et al. (1968) observed slightly a higher value of these cultivars i.e. Banarasi 48.60 g, Chakaiya 30.00 g and Bansi Red 27.76 g. Pathak et al. (1985) reported the fruit weight of Kanchan and Krishna cultivars of aonla as 40.00 g and 32.00 g, respectively. Singh and Arora (1967) reported among the two cultivars of aonla i.e. Chakaiya and Banarasi fruit specific gravity was more in Chakaiya (1.10) than in Banarasi (1.02) whereas, the fresh fruit weight of cultivar Banarasi was 38.50 g and Chakaiya 29.70 g.
Ladaniya (2004) observed the fruit weight in Mosambi as 185.0 g with marginal increase up to 220 days. Yadav et al. (2003) conducted an extensive survey in Meghalaya during the year 2000 and reported that reduction in yield and fruit weight of Khasi mandarin was more than 82 percent and up to 30 percent respectively in declined orchards. The study revealed that yield, fruit weight, fruit size, rind thickness varied in declining orchards.

Kumar et al. (2010) evaluated different citrus species/cultivars under Arunachal Pradesh conditions. Maximum plant height and fruit weight were observed with Mediterranean orange. Zigardio mandarin recorded the highest leaf length, leaf breadth and bigger size fruit. Mandarin cultivars were devoid of thorn however; very small thorns were noticed in King Theppi and Khasi mandarin. Khasi mandarin recorded comparatively more segments than other mandarins. Maximum plant height and big size fruits were observed with Washington Malta sweet orange. Italian large and Vanilla Malta recorded the highest leaf length and breadth while the least length was recorded with Ruby Blood Red. The lower fruit weight was recorded with Italian large. The seed number varied from as low as one in Washington Malta to as high as fifty five in tagu. Tanyum was bushy type with very long and sharp thorns. C. Jawanica recorded the highest leaf length and breadth. Trifoliate plant with its distinct leaf characteristics was borne with very small leaves than other plants. Karna Khatta recorded comparatively bigger sized fruit while Cleopatra mandarin was smaller in size. The rind colour was deep orange for Cleopatra mandarin to light yellow for Cleopatra latipes. Tanyum had profuse seeds followed by Cleopatra latipes.

2.2 Bio-chemical parameters

Chukwuka, et al.(2013) studied the nutritive value of Carica papaya (L.) fruit at different ripening stages with the aim to advise consumers and biological world regarding the best time to consume the fruit. Proximate, mineral and vitamin analyzed for the pulp of papaya fruit. Results showed that fresh ripen papaya is a good source of Moisture 89.21 percent, Dry matter 10.79 percent, Crude fibre 6.18 percent, Protein 0.64 percent, fat 0.35 percent, Carbohydrate 9.65 percent (these content decreases as it gets ripen), Minerals (Calcium 14.69 mg, Sodium 25.68 mg,
phosphorus 9.48 mg per 100 g), Vitamins (Riboflavin 0.07 mg, Vitamin C 112 mg and Thiamine 0.08 mg per 100 g). Very ripen papaya is not a good source of protein because unripe papaya contains more protein. Unripe papaya contains the highest amount of all the non-nutritive elements (Saponin, Alkaloid, Tannin, Flavonoid and Phenol) which are beneficial to the body. In view of these differences, though very ripe pawpaw is sweet and good for consumption, the unripe pawpaw is recommended for use due to its nutritive value.

Katarzyna and Magdalena (2013) reported that eggplant cultivars differ from one another in a number of properties, among others, earliness of fruiting and length of fruiting period in Poland. The assessment of marketable yield of five eggplant cultivars Black Beauty; 85.7, Classic F₁; 125.1, Avon F₁; 188.9, Epic F₁; 210.6 and Vernal F₁; 237.9 q/ha respectively, fruits harvested in different stages of maturity. The results of chemical analysis proved that fruits in optimum maturity contained 8.73; 5.63, 9.27; 5.19, 9.83; 5.11, 8.66; 4.50 and 9.51 percent; 4.66 mg/100 g dry matter and Vitamin C content in Black Beauty, Classic F₁, Avon F₁, Epic F₁ and Vernal F₁ respectively, in comparison to elder fruits.

Vrsaljko (1998) examined the chemical composition viz. carbohydrates (total sugars, reducing sugars, sucrose and starch), proteins (amino acids, arginine, glycine and methionine), fractions of proteins (albumin, globulin, gluten and prolamine) and lipids (fatty acids, palmitic, stearic, oleic and linoleic acids) of almond cultivar Ferragnes, cultivated in Ravni Kotari, Croatia. The level of lipids recorded between 43 and 49 percent, the proteins at about 20 percent, and sugars at 4.25-5.70 percent. In 1993, the levels of lipids were higher (14 percent) while those of the sugars and proteins (globulin, gluten and methionine) lower compared to those of 1994. In the same year, the proportion of unsaturated fatty acids (palmitic and stearic acids) was higher than that of oleic acid.

Arivalagan et al. (2013) reported that moisture 92.72 percent and iron 0.85 mg/100 g fresh weight basis in eggplant (Solanum melongena L.) and also noted it is one of the most popular and major vegetable crops grown in South Asia and other parts of the world. It is an important source of plant-derived nutrients like minerals, available throughout the year and popular among the poor population.
Potato is an important crop for the higher population area of Asia because it produces more dry-matter food, well balanced protein and more calories from per unit area of land and time than other major food crops. Thamburaj and Singh (2001) reported 1.6 g protein, 0.1 g fat, 22.6 g carbohydrate, 0.01 mg riboflavin and 40 mg phosphorus per 100 g fresh weight basis in potato.

Thangam and Thamburaj (2008) studied on effect of shade on growth, yield and quality of six cultivars and fourteen hybrids in tomato (Lycopersicon esculentum Mill.) under agro shade net (50 percent) and in open field simultaneously during consecutive summer seasons. Highest yield recorded in Avinash-2; 2642.9 g Naveen; 2303.4 g and S- 41; 2129.8 g per plant in open field. In respect of biochemical constitutions like ascorbic acid 19.80 mg; 26.65 mg; 23.83 gm/100 g and dry weight (42.34, 53.33, and 32.42 g/100 g), fruit length (7.10, 6.20, 5.65 cm); fruit weight (46.65, 42.60, 37.40 g).

Unnithan (2008) studied chemical composition of 12 pawpaw (Carica papaya L.) fruits cultivars (Co-2, Co-3, Co-4, Co-5, Coorg Honey Dew, Sunrise Solo, 9-1D, Thailand, Tainung, Pusa Dwarf, Pusa Nanha and Washington) grown in Trivandrum, Kerala, India. Sunrise Solo registered the highest TSS content (14.78 degrees Brix), non-reducing sugar content (10.84 percent), total sugar content (19.66 percent), and carotenoid content (2.48 mg/100 g). The highest reducing sugar content was recorded for Coorg Honey Dew (11.88 percent). The ascorbic acid content was highest for Co-3 (131.26 mg/100 g) and lowest for 9-1-D (66.18 mg/100 g). Zaman et al. (2006) carried out a study on four cultivars of Papaya (Carica papaya L.) namely Bombai, Deshi, Shahi (Yellow) and Shahi (Red) for their physico-chemical composition, grown at Rajshahi, Bangladesh. The range of Vitamin C content was 41.0 to 42.40 mg/100 g of pulp. Vitamin C content was higher in the cultivar Bombai 42.40 mg/100 g followed by Shahi (Yellow) 42.00 mg/100g, Shahi (Red) 41.60 mg/100 g and Deshi 41.00 mg/100 g.

Othman (2009) determined the proximate composition (crude fat, crude fibre and moisture), ascorbic acid, macro-nutrients and heavy metal contents of storage-ripened papaya (Carica papaya L.) fruits from Mbezi, Dar es Salaam, Tanzania. The determinations were repeated for early, middle and late-season papaya fruits. The
fruits harvested at the mature green stage and allowed to ripen during room temperature storage. The results showed that papaya fruits had high moisture content (85.9 to 87.62 percent), low crude fat (0.10 g/100 g-edible portion), moderate crude fibre (1.45 g/100 g edible portion), high ascorbic acid content (83.78-85.85 mg/100 g fresh weight), content. Of the determined macro-nutrients (Calcium-21.44 mg/100 g, Sodium-3.26 mg/100 g, potassium content (420 mg/100 g fresh weight basis) was the highest. Heavy metals content (Iron-0.21 mg/100 g fresh weight basis) was very low in the papaya fruits. Variations in moisture content and ascorbic acid content were observed during the season and during the ripening period.

Devi et al. (2007) advocated vegetables are the best resource for overcoming micronutrient deficiencies in developing countries. Many indigenous vegetables, especially the leafy vegetables are rich sources of vitamin A, C and minerals like iron, calcium, phosphorus, sodium, potassium and many others. Kerala, located in the warm humid tropics enjoys a wide range of climate conditions suitable for growing a wide range of indigenous leafy vegetables cultivar, most commonly amaranth, drumstick, chekkurmanis and waterleaf.

Ramulu and Rao (2003) reported that fruits such as fig, mango, orange, papaya and sweet lime are rich sources of soluble dietary fiber (SDF), the component of total dietary fiber (TDF) associated with a number of health benefits. Among the mango cultivars, Banganapalli and Eruman appear to be better sources of SDF than others. The data generated in the study on TDF, insoluble dietary fiber IDF and SDF contents of different fruits will be useful in selecting appropriate fruit rich in SDF for incorporation into the Indian diets to promote better health. Also they can be included in the food composition tables, which in turn, will help dieticians to plan SDF rich diets for diabetic and hyperlipidemic person.

Singh et al. (1997) revealed the chemical composition of four cultivars of vegetable pea’s viz. Arkel, Bonneville, Azad P1 and Rachna at green and tender stage. Bonneville cultivar recorded the highest nutritive value with regard to dry matter, protein, sugar, ascorbic acid and mineral contents followed by Arkel. Rachna expressed relatively higher starch and crude fibre contents. No single cultivar was
found to be the superior in quantitative & qualitative characters. Some were good in yield while others were rich in the vital food constituents.

Rai et al. (1987) screened out 20 cultivars of tomato and Angoorlata was found superior as it contained 6.76º Brix TSS and proved superior over other in respect quality and suitability for salad and processing purpose.

Rao and Sharma (1987) determined the chemical composition and the nutritional value of protein of whole as well as solvent-extracted fenugreek seeds. Fenugreek seeds are rich in protein (25.5 percent), fat (7.9 percent), unavailable carbohydrate (48 percent), mucilaginous matter (20 percent) and saponin (4.8 percent). The replacement of casein diet up to 10 percent by fenugreek seeds (extracted) did not produce any deleterious effect on protein quality of casein as assessed by protein efficiency ratio (PER), protein and dry matter digestibility and net protein utilization (NPU). Further increasing the level of fenugreek did reduce these parameters. The extraction of seeds improved, and cooking did not alter the quality of fenugreek seed protein.

Roy and Singh (1979) reported that Bael (Aegle marmelos) fruit is highly nutritious. It contains 61.5 g water, 1.8 g protein, 0.39 g fat, 1.7 g minerals, 31.8 g carbohydrates, 55 mg carotene, 0.13 mg thiamine, 1.19 mg riboflavin, 1.1 mg niacin, and 8 mg per 100 g of edible portion vitamin C. No other fruit has such a high content of riboflavin. Marmelocin is most probably the therapeutically active principle of bael fruit.

Hazarika et al. (2009) reported that aonla is found scattered throughout Jorhat district of Assam. A survey was carried out to identify the elite genotypes among its natural population. The ripe fruit of 14 selected types were analyzed for chemical traits like TSS, acidity, ascorbic acid, reducing sugars and total sugars. Total soluble solids varied from 12.0 to 19.0 percent; titrable acidity 2.29 to 4.61 percent; ascorbic acid 400 to 850 mg per 100 g, reducing sugars 3.76 to 10.98 percent. Singh et al. (1987) reported chemical composition of four cultivars of aonla i.e. Banarasi, Chakaiya, Desi and Harpharori to contain 636.8, 474.5, 458.9 and 598.0 mg per 100 g ascorbic acid and Bajpai and Shukla (1990) also reported
moisture 81.2 percent, protein 0.5 percent, carbohydrate 14 percent, calcium 0.35 percent, phosphorus 0.02 percent, iron 0.01 percent and vitamin C 600 mg per 100 g in aonla fruits.

Deka et al. (2007) studied chemical changes of pineapple fruits during summer and winter season. They noted specific gravity, TSS, sugar and vitamin C. Attributes which varied both the seasons. The ascorbic acid was noted 18.14 and 15.32 mg/100 g during respective seasons. Specific gravity was recorded as 0.98 and 0.97 during winter and summer seasons. Sen (1990) reported the chemical composition of pineapple fruit as moisture (80-85 percent), fat (0.1 percent), calcium (0.02 percent), phosphorus (0.01 percent), iron (0.09 percent) and vitamin C (30.0-50.2 mg/100 g).

Achinewhu and Hart (1994) revealed that Ascorbic acid contents of the juice of four different pineapples species grown in the Rivers State of Nigeria determined before and after storage of whole pineapple and processing and storage of the juice for two months. Ascorbic acid of the fresh juice ranged from 22.5 mg to 33.5 mg/100 g sample. After storage at room temperature (30-32 degrees C) of whole pineapple for two weeks, ascorbic acid was reduced to between 59 and 65 percent of the fresh juice. Processing the juice by pasteurization reduced the ascorbic acid to between 28 and 46 percent while storage in plastic bottles for two months further reduced the ascorbic acid content to between 10 and 21 percent.

Yadav et al. (2003) conducted on extensive survey in Meghalaya during 2000 and reported that juice content and T.S.S./acid ratio varied in declining orchards of khasi mandarin, whereas, ascorbic acid and acidity in fruits had the increasing trend. It was also recorded that the productivity was also declined. Ghosh and Chattopadhyay (1998) studied seven cultivars of sweet oranges. Washington Naval was found to produce heaviest fruits but poor in quality. The fruit of Musambi was medium in size and best in quality. The ascorbic acid content was highest in Ruby and lowest in Jaffa. Experimental evidences show that different species of citrus fruits have different chemical composition. Ghosh et al. (1990) reported protein 1 g, carbohydrate 13 g, fibre 6 g and potassium 270 mg per 160 g flaks of most common sweet group citruses.
2.3 Yield of Fruits and Vegetables

Bahadur et al. (2013) conducted a two year study to determine the response of a tomato crop for three planting systems and three mulch materials. Results indicated that planting systems significantly influenced the soil moisture regimes; weed growth and water use efficiency but did not affect the yield and other parameters. Mulch materials significantly influenced the hydrothermal regime of soil, physiological traits, yield and water use efficiency. As for as the interaction of planting system and mulch is concerned, the maximum dry matter production (231.03 g/plant), fruit yield (449.36 q/ha) and water use efficiency (143.57 kg/ha-mm) was noticed under raised bed planting coupled with paddy straw mulching. This combination also saved about 49% water with 55% higher yield over absolute control. Thangam and Thamburaj (2008) studied on effect of shade on growth, yield and quality of six cultivars and fourteen hybrids in tomato (Lycopersicon esculentum Mill.) under agro shade net (50 percent) and in open field simultaneously during consecutive summer seasons. Highest yield recorded in Avinash-2; 2642.9 g Naveen; 2303.4 g and S- 41; 2129.8 g per plant in open field.

Luthra et al. (2008) revealed one hundred ninety five potato germplasm accessions including five cultivars were evaluated for tuber yield and its components during three consecutive crop seasons and data were analyzed for stability. Average tuber weight was found more stable than tuber yield and tuber number. Stable accessions were not necessarily high yielding too. Accessions namely CP1172, CP1231, CP1233, CP1304, CP1329, CP1338, CP1367, CP1441, CP1442, CP1456, CP1515, CP1555 and Kufri Pukhraj were found to be ideally adapted to North-central plains for total tuber yield and marketable tuber yield owing to significant high mean, non-significant unit regression (bi) and least deviation from regression (S2di). Among these, CP1329 and CP1515 were stable for the maximum of four characters and could be valuable material for adaptability and yield improvement in potato. The accessions namely CP659, CP1057, CP1086, CP1143, CP1181, CP1310, CP1314, CP1316, CP1330, CP1353, CP1358, CP1373, CP1483, CP1485, CP1546, CP1548, CP1591, CP1615, CP1619, Kufri Anand and Kufri Ashoka were responsive to favourable years for total tuber yield and marketable tuber yield.
Accessions responsive to unfavourable years possessed low or average mean performance for various characters.

Yield of fruits varies greatly owing to its contributory component e.g. length, diameter and weight. Apart from cultural practices, use of manure and fertilizer, plant protection measures, genetic constitution play significant role in altering the yield. Sharma et al (2011) found 69.2 and 73.8 q/ha average yield of green pods of okra grown under integrated nutrients. However, Thamburaj and Singh (2001) reported the average yield 80 q/ha of green pods of okra during spring-summer season and 125 q/ha during rainy season by high yielding cultivars.

Marwaha et al. (2009) conducted field trials at Shillong during summer season in 2005 and 2006 to evaluate an advanced potato hybrid, MP/97–644 along with three processing cultivars viz., Kufri Chipsona-1, Kufri Chipsona-3 and Atlantic and one popular table cultivar, Kufri Jyoti for yield, chipping quality and some important processing attributes. Hybrid MP/97–644 produced maximum tuber yield (194 quintal per hectare), high processing grade tuber yield (98 quintal per hectare), acceptable chip colour (2.2), high tuber dry matter (24.1 percent), contained permissible level of reducing sugars (38.4 mg/100g fresh weight) and was moderately resistant to late blight. Conversely, Kufri Jyoti produced lower yield and minimum dry matter content (17.3 percent) and contained maximum total phenols (107 mg/100 g fresh weight), which are undesirable processing traits. Based on maximum total yield, higher proportion of processing grade tubers, superior processing traits and resistance to late blight, MP/97–644 was identified as the most suitable hybrid for chipping as well as for table consumption followed by cultivar Kufri Chipsona-1.

Phookan and Shadeque (1996) studied the performance of 29 cultivars of tomato (Lycopersicon esculentum) during summer season under the agro-climatic condition of Jorhat (Assam). The highest fruiting percent of 48.5 followed by 38.7 percent were recorded in the cultivar BTI and AC- 238 respectively. Ultimately the highest yield of 4588 g per plant with 101 fruits and 4000 g per plant with 23.3 number of fruits and 3800 g per plant with 40 numbers of fruits were obtained in the cultivars BTI and Arka Alok and A C-238 respectively.
Rai et al. (1987) evaluated a number of cultivars of tomato to screen out suitable ones for Tripura conditions. Among 20 cultivars of tomato (*Lycopersicon esculentum*) tested for two years (1978-79 and 1979-80), the cultivar S-12 gave a recorded yield of 499.44 q/ha with overall best performance in comparison with other cultivars. This cultivar (S-12) gave maximum yield during both the years which attributed to capacity of this cultivar to yield more. Cultivar Marglobe ranked second best in yield potential and borne large size fruits. The highest TSS (6.76 percent) recorded from the cultivar Kufri Anglorlata and ranked 3rd as far as yield is concerned. Because of its good quality and higher TSS this cultivar is suitable for salad and processing purposes.

A bird’s eye-view on above literature reveals a conspicuous gap in the lack of understanding of quality of fruits and vegetables of northeast India in general, and Arunachal Pradesh in particular. Hence, the present investigation has been taken up to the study in biochemical quality and its storage of selected fruits and vegetables in Arunachal Pradesh, which will help improve state and national economy and prosperity of the country.