The Pharma Innovation Journal 2022; 11(7): 2435-2447

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(7): 2435-2447

www.thepharmajournal.com
Received: 08-05-2022
Accepted: 16-06-2022

Poluri Harsha Vardhan
M.Sc. Student, Department of Food Science and Technology, Lovely Professional University, Punjab, India

Corresponding Author:
Poluri Harsha Vardhan
M.Sc. Student, Department of Food Science and Technology, Lovely Professional University, Punjab, India

Effect of different drying techniques on nutritional composition of arid zone fruits

Poluri Harsha Vardhan

Abstract
Drying has become necessary, because most fruits are highly perishable due to presence of high moisture content and to make fruits available all year round and at different locations majorly where they are not produced. Due to the increased consumption of dried fruits requires further attention on the quality parameters. Drying has beneficial effect like preservation (increase shelf life period), and reduced weight and bulk density of dehydrated products decreases packaging cost, handling and transportation costs. The current review paper gives the information on the effect of different drying techniques on nutritional composition of arid region fruits. Different drying methods are used to develop the more retention of nutrients. Among the drying methods freeze drying was observed the better retention of phenolic compounds, flavonoids, and antioxidant activity. Physico-chemical characteristics of different arid zone fruits was studied and observed decrease of moisture content from and significant changes in proteins and carbohydrates, minerals. Better retention of colour was observed in freeze drying. Fruits like Aonla are rich in ascorbic acid which is lost or degrade during different process of drying. Fluidized bed drying shows the highest retention of ascorbic acid content. More retention of nutrients in date palm fruit was observed during microwave drying. It was observed that low temperature drying process give more retention of nutrients and hence it is recommended.

Keywords: Drying, freeze drying, flavonoids, antioxidant activity, microwave drying, phenolic compounds

Introduction
The term Arid originated from the Greek word 'Arere' which means dry, as precipitation is less than 200mm (Sergio and Franco, 2021) [81]. Arid and semi-arid regions have very harsh environmental conditions like irregular rainfall and more sunlight, heavy winds, coarse soil texture, less water holding capacity followed by poor nutrient in soil (FAO, 2017).
2547 million hectares of area around the world having arid zone in which Africa continent stood first in the world (41.6%) followed by Asia (35%). Around 31.70 million hectares of land in India covers hot arid zone. There are 6 arid zone areas present in different states of India which includes Western Rajasthan, Punjab Haryana, Gujarat combined as Thar desert that accounts 89.6%of hot arid zone. Andhra Pradesh, Karnataka, Maharashtra occupies 10% of the arid zone (known as peninsular hot arid zone) (Roy, Tiwari *et al*., 2012)
Due to availability of more arid region and increase in demand for arid zone fruits because of their nutritional content, area and production of arid zone fruits increasing day to day. As per the report given by (National horticulture board, 2019) area and production of Aonla was (92 mill ha, 1039 MT), Ber (52 mill ha, 639MT), pomegranate (262 mill ha, 3034MT), Tamarind (49 mill ha, 202 MT).
Certain fruits have tolerance to abiotic stress and good cultivation practices with in the harsh environmental conditions helps in getting more production/ yield (Singh *et al*., 2016) [75]. Selection of crop for production is dependent on the rainfall (Singh *et al.*, 2013) [92]. Underutilized fruits, vegetables have a good source of energy, vitamins, proteins, minerals, carbohydrates, fats, and dietary fiber. Many of these fruits have the capacity to prevent diseases like kwashiorkor, marasmus, diabetes, night blindness. Cultivation of these crops provides economic security to tribes. There are several factors responsible for deterioration and improving the quality and nutritional composition of fruits (Nandal and Bharadwaj, 2014) [81].
Drying is one of the oldest preservation methods available since prehistoric times. Today, dried foods play an important role in the food supply chain. For the fruits and vegetables, it can be estimated that approximately 1% of the total drying technique utilized in the food industry (grains the most important).

The main feature of this process is to reduce the water content to slow down the food spoilage by microorganism. Common words found are "drying" or "dehydration" or "dewatering" (Ahmed, Naseer *et al*., 2013).

Production scenario (National)

However arid regions have high temperatures and irregular rainfall and poor soil health, leads to less productivity. Utilization of suitable cultivars and propagation methods and age-old cultural practices to attain maximum crop value (Singh and Mishra, 2020) [79].

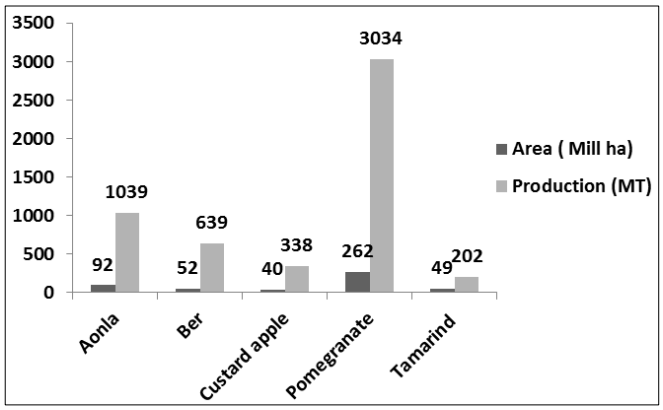

Fig 1: Area and production of fruits grown in arid region (2018-19) (NHB, 2019)

Cultivation practices in arid region

Selection of crop: The selection of crop is dependent on deep root system as well as xerophytic characters such as hairs, waxy coating, spines. Fruiting should complete in shortest time. It should be tolerated to salinity. High yielding varieties should be selected (Saroj *et al*., 2020) [13].

Propagating material: According to Singh *et al.*, (2020) the major problem in development of horticulture scenario in arid parts of the country is lack of quality seed and planting material. Planting material is a precious input to increase quality production of fruit crops. Thus, production of quality planting material and their supply to farmers will boost up the arid horticultural crops production.

Sowing time: Different fruit crops having different sowing time. Some seeds germinate in short time and some took long time. Short germination seeds should be sown lately and vice versa. Depending on their germination, any fruit crop is sown in such a way so that critical stages of fruit life cycle will co-inside with rainfall/precipitation. Like Aonla (May-August), Ber (July- August) (Singh *et al*, 2020), Datepalm, Tamarind (July- August) (Singh *et al*, 2020)

Irrigation: The annual average rainfall in the arid regions is very low, erratic and varies from 100 mm to 450 mm in the eastern boundary or arid zone of Rajasthan. Most of the precipitation in north western arid region occurs during July-September in about 19-21 rain spells. Due to low and irregular rainfall pattern in arid region, there is need of increase in appropriate technology increase productivity. Water is precious input in hot arid region of the country therefore, adoption of micro-irrigation and rainwater harvesting system is desirable to save water and enhance productivity (Saroj *et al*., 2020) [13].

Climate: The maximum annual rain fall which tamarind can tolerate is up to 4,000 mm (Singh *et al*., 2021).

Cultural practices: As reported by Saroj *et al*, (2019) [46] locally available and easily decomposable organic materials like paddy straw, maize straw, grasses, husk, etc. can be applied with 20 cm thickness after rainy season which were found beneficial for improving the soil quality, growth and yield. Mulches not only conserve soil moisture and moderate soil temperature, but also impart manifold beneficial effect on earthworm and microbial population, soil fertility and growth and yield of plant. Data given by Singh *et al*., (2020) during initial years of orchid establishment, intercropping with vegetable crops is done.

Arid region fruits

AONLA (*Emblica Officinalis*): It is a dry arid region fruit belongs to Euphorbiaceae family. In ancient literature it is called as "Amritphal" (Singh *et al*, 2015). Aonla fruits are round shape, yellowish green color and deeply ribbed towards seed. it is second rich fruit in vitamin C after Barbados cherry. It can grow naturally on hills up to 1800 altitude. Many countries importing this fruit due to its medicinal value in ayurveda. According to (National horticulture board, 2019) India produces 1039 MT of Aonla. Patch budding most commonly preferred for the commercial cultivation of the fruit. Irrigation during critical stages for good yield. The shedding of the fruit starts in December followed by flowering in February (Singh *et al*, 2020). 2015-16 0.972 million metric tonnes of Aonla is produced in India, out of which contribution of Uttar Pradesh, Madhya Pradesh and Tamilnadu is 75.88%. It is used in making traditional pickels, and sweets like amla murabba during festivals. (Tewari *et al*, 2019) [15]. Aonla is used in treatment of scurvy, due to high content of Vitamin C. it is used in jaundice, anemia, cough, desentry and indigestion problems (Saini and Sihag, 2020) [16] (Gorakh, Mishra, 2007) [20].

According to (Singh *et al*., 2013) Aonla contains minerals like calcium, phosphorous, iron. It contains 4.45% tannins, ellagic acid, gallic acid, epicstechin, linoleic acid 44%, linolenic acid 8.78%, oleic acid 28.4%, stearic acid 2.15%, palmitic acid 2.99%, myristic acid 0.95% all these helps in decrease the frequency of heart attacks. It is richest source of vitamin- C among fruits except Barbedos cherry and contains 500-1800mg ascorbic acid per 100g (Singh *et al*., 2019).

100 grams of edible portion of Aonla contains 0.5gm protein, 0.1gm fat, 13.7gm carbohydrate, 50mg calcium, 20mg phosphorous, 1.2mg iron, 500mg vitamin C. The variation in the vitamin C and fiber content depends on different cultivars such as Banarasi contains 0.32g fiber and 484mg/100gm vitamin C, kanchan having 0.95gm fiber and 504mg/100gm vitamin C, franc is having 0.65gm fiber and 566.5mg/100gm vitamin C. 50% of protein, 0.10% fat, 0.50-0.70% minerals, 1.90-34% fiber, 0.012-0.050 calcium, 0.020-0.026 phosphorous, 1.20mg/100mg iron, 0.20 mg/100mg nicotinic acid, 0.01 mg/100mg carotene, 0.03 mg/100mg thiamine, 0.05 mg/100mg riboflavin, 0.18 mg/100mg niacin, 3.0 mg/100mg tryptophan, 2.0 mg/100mg methionine, 17 mg/100mg lysine (Murthy and Joshi, 2017).

According to study Saroj *et al*, (2020) [13] Fruit has acidic, cooling, refrigerant, laxative and diuretic properties. Dried fruits are useful in curing chronic dysentery, diarrhoea, diabetes, dyspepsia, cough, anemia and jaundice.

BER (*Ziziphus mauritiana*): It is one of the arid region fruits belongs to Rhamnaceae family. Origination country of *Ziziphus jujube* is china. *Ziziphus mauritiana* is the native cultivar of India. it is also known as ber/ Indian plum/ desert apple. The tree can grow up to 4-10m height with yellow coloured Flowers. Fruit is round in shape with red colour in ripen form whereas green colour in unripe. The tree is tolerant to acidic, slightly alkaline soils and highly resistant to drought condition. Leaves used for improving sleep disorders and reduce diarrhea. Bark used to cure wounds. The Fruit of *Ziziphus Mauritiana* used as a Iranian medicine for reducing blood pressure and anticancer, anti-inflammatory, antiobesity (Shahrajabian *et al*, 2019) [30]. There are 700cultivars of ber out of which 6 species are used for commercial cultivation. Seed contains saponins. All tree parts are used in traditional Chinese and iranian medicine. China is leading produce of common jujube (450,000 t). The fruit can be eaten as fresh, dried fruit candies, paste, pickles (Wojdylo *et al*., 2016). Jujube tree distributed in tropical and subtropical regions of Asia, Russia, Africa. Fruit is called drupe (Maraghni *et al*., 2010). Rajasthan covers 3200 hectares and produce 28,000 tonnes. Vegetative propagation is carried by budding for good yield. Well-mannered training and pruning can also increase the yield of crop. (Dubey *et al*, 2013) [33].

A study conducted by Sunil and Parak., (2013) [1] stated that 100 grams of fresh jujube pulp comprises of protein 1-1.5gm/100gm, lipids 0.1-0.25gm/100gm, carbohydrate 20-21gm/100gm, and minerals like calcium 20-21.5mg/100gm,iron 0.4-0.6 mg/100gm,magnesium 10-11 mg/100gm, phosphorous 20-24mg/100gm, potassium 250-255 zinc 0.05-0.06 mg/100gm, sodium 2-3.5 mg/100gm, and vitamins like thiamin 0.01-0.02 mg/100gm, riboflavin 0.03-0.05 mg/100gm, niacin 0.9-1.1 mg/100gm, Vitamin B6 0.08-0.09 mg/100gm (Plastina *et al*., 2016). and also comprises of different types of phenolic compounds 275- 541mg/100gm of fresh weight, flavonoids 62-284 mg/100gm of fresh weight, anthocyanins 29- 43 mg/100gm of dry weight, carotenes 4.1-6.1 mg/100gm of dry weight (Chen *et al*, 2015). According to studies tell that total soluble solids in jujube fruit range from 14-15.1 degree Brix, titratable acidity 1.7-5.5 MSI, and pH ranges from 4.7-6.4 based on different varieties/ cultivars (Krishna *et al*., 2013)

(Pareek and Sunil 2013) [1] 100 grams of jujube fruit contains 81-83gm of moisture, 0.8gm of protein, 0.07gm of fat, 0.6gm of fiber, 17gm of carbohyderates, 5.4-10. Gm total sugars, 1.4-6.2gm reducing sugars, 3.2-8gm of non-reducing sugars,0.3-0.5gm ash, 25.6mg calcium, 26.8mg phosphorous, 0.7-1.8mg iron, 0.021mg carotene, 0.02-0.024mg thiamine, 0.02-0.03mg riboflavin, 0.7-0.87mg niacin, 0.2-1.1mg citric acid, 65.8-76mg ascorbic acid, 0.1-0.2ppm fluoride, 2.2-3.4% pectin.

Consumption of jujube fruits has a major role in anticancer properties, antiobesity, hepatoprotective property, gastrointestinal protective property, anti-inflammatory property, immune-stimulating properties, inhibiting the hemolytic activity of human serum (Krishna *et al*., 2013)

Pomegranate (*Punica granatum*): It is one of the arid zone fruits that belong to the family Punicaceae. It is originated in middle east Iran and domesticated from 400-300BC (Meena *et al*, 2018) [39]. The fruit is introduced to china and India over the silk road. It is the symbol of health, fertility and rebirth, mentioned in ancient cultures. Approximately 613 seeds are present in single fruit and each one represents Bible's 613 commandments. It is one of the oldest edible fruits (mention in Bible and Quran). Initially it was called as *Malum punicum* by Romans whereas later on the name *Punica granatum* was given by linneaus (Chandra *et al.*, 2010) [41].

Outside it is covered with leathery peel (reddish pink) and inside Arils are partitioned with diaphragms (bitter, yellow colour). Grains are pink red, sweet and pleasant aroma, seeds are soft and whitish pink (Blumenfeld, shaya *et al*, 2000) [40]. Maharastra is the leading state in area and production of pomegranate in India followed by Karnataka, Gujarat, Andhra Pradesh. Edible portion of the fruit is seeds and arils. An aerage edible portion of fruit is around 50-60% and which includes 20-22% seeds and 80% juice recovery (Pareek and Sunil 2013)

There are more than 500 cultivars of pomegranate are already identified. It is a non climatric fruit which cannot ripe after harvesting (Pareek and Sunil 2013) Vegetative propagation of this fruit is done by air layering. The sprouting period of the fruit is spring season and harvested in summers. It is consumed as fresh and by making juice. Pomegranate is a light loving plant and responds negatively to shade. It cannot tolerant to low temperature <18degrees (Chandra *et al.*, 2010) [41]. Fruits are graded for better market value. Four grades seen in pomegranate i.e. super-size 750gm, king size 500-700gm, queen size 400-500gm, prince size 300-400gm fruit weight (Meena, Asrey *et al*. 2018) [39].

It also contains 85-86% moisture and 10.5-10.9% sugars, 1.3-1.4% pectin, 1.2-1.41% protein, 0.2-0.34% fat, 1.4-1.6% crude fiber, 14.5-15.5% carbohydrates, 16.2-16.8 total soluble solids, minerals like iron 0.3-0.39mg/100mg, zinc 0.19-0.26mg/100mg, calcium2.50-2.71 mg/100mg, magnesium 7.7-10.2 mg/100mg, copper 0.26-0.28 mg/100mg, manganese 0.13-0.15mg/100mg, phosphorous 28.2-34.7 mg/100mg, vitamins like Thiamine 0.06-0.09 mg/100mg,niacin 0.22-0.25 mg/100mg, ascorbic acid 22.3-22.49 microgram/100gm. Fuit peel contains of anti-nutritional factors like phenols and flavonoids (Jahromi, 2018) [42] (Chandra *et al.*, 2010) [41].

(Nyik, Ahmad *et al.*, 2020) reported 100 grams of edible parts of pomegranate arils contains 80.9g/100g water content, 0.95 g/100g protein, 17.1 g/100g carbohydrates, 0.30 g/100g fat, 16.57 g/100g total sugar, 0.6 g/100g dietary fiber, 108 IU/100g vitamin A, 50 µg/100 g alfa carotene, 40 µg/100 g beta carotene, 6.1 mg/100g vitamin C, 0.6-0 6.1 mg/100g vitamin E, 4.6- 6.1 mg/100g vitamin K, 6.1 mg/100g phytosterols, 2.95 mg/kg potassium, 30 mg/kg sodium, 30 mg/kg magnesium, 30 mg/kg calcium, 3 mg/kg iron, 1.2 mg/kg zinc, 0.7 mg/kg copper and seed part contains 8.60g/100g moisture, 2g/100g ash,13.2 g/100g protein, 27.32 g/100g fat, 49 carbohydrates, 35.3 g/100 g crude fiber, 4.2 g/100 g total sugar, 6.0 g/100 g pectin, 10.2 mg/100g vitamin C, 0.08 mg/100g vitamin B6, 37.93 µg/100 g foliate, 16.44 µg/100 g vitamin K, 235.6 mg/100g potassium,12.4 mg/kg magnesium, 35.6 mg/100g phosphorous, 1.3 mg/kg iron, 1.3 mg/kg copper, 1 mg/kg zinc and fatty acids are 65.3 g/100g punicic acid, 2.16 g/100g caproic acid, 0.955 g/100g capric acid, 5.13 g/100g oleic acid, 6.6 g/100g linoleic acid, 6.62 g/100g lauric acid, 7.56 g/100g myristic acid, 4.8 g/100g palmitic acid, 0.47 g/100g palmitoleic acid, 2.3 g/100g stearic acid and fresh peel powder contains 5.49 g/100g ash, 3.95 g/100g crude protein, 12.61 g/100g crude fiber, 4.29 g/100g lignin, 40.53 mg/g polyphenol, 14.06 µg/g vitamin A, 763.6mg/kg sodium, 16.2 mg/kg potassium, 645.7 mg/kg

calcium, 1644 mg/kg magnesium, 33.96 mg/kg phosphorous, 22.6 µg/g iron, 6.2 µg/g copper, 8.03 µg/g zinc.
Fruit is used to cure leprosy. Each and every part of the plant has been tested for antimicrobial activities, anticancer activities, anti-inflammatory effect (Jahromi, 2018) [42].

Date palm (*Phoenix Dactylifera*): It is one of the arid region fruits that belongs to Family: Arecaeae/ palmaceae. It is one of the most important trees in Arabian countries. The genus Phoenix contains 14 species (Pintaud *et al.*, 2013) [49]. The name originated from Greek Phoenix means purple or red and dactylifera means figure like projections of fruit bunch. Average economis life of tree is 40-50 years (Chao and Krueger, 2007) [52].
Date palm cultivation was started in middle east during Islamic era. Early occurrence of date palm was noticed in united Arab emirates during Neolithic period from 5290-4940 cal BC (Tengberg., 2012). Consumption of date starts from 6th millennium BC (Balthazard *et al.*, 2018) [50]. Egypt produces 13,52,950 MT followed by Sudi produces 10,78,300MT, Iran produces 10,23,130MT. (Ghori *et al.*, 2018) [51].
Flowers are called fruit sets in female trees. Fruit goes through different ripening stages "Kimri" is immature green, "Khalal" is mature coloured, "Rutab" is soft brown, "Tamar" is hard resin (Iraqi Arabic) (Chao and Krueger, 2007) [52]. Fruit can be eaten as fresh, dried, paste.
It provides rapid energy due to more carbohydrate content (glucose and fructose) which is easily absorbed by the human body. Date seeds are used as feed for animals (Hibab, Hosam *et al.*, 2009). Tree can grow up to 20-30m height. Stems and wood are used as a fuel wood and construction works. Leaflets and surrounding fibers around leaf is used in basket and rope making. Trunk is used in construction, leaves used in preparation of baskets. Leaf fibers used in mat, ropes preparation. Production of natural fibers from the plant having great market value due to it light weight, high strength, and good stiffness. These are easily recyclable. Datepalm fiber is one of the waste material and grown in Saudi Arabia. It is the first most essential tropical fruits after pineapple and citrus. Fruit contains phenolics, sterols, flavonoids etc. having antimicrobial and anti-inflammatory, anticancer activities. Fruit is considered as complete diet due to its nutritional value (Far, Emmanuel *et al*, 2018) [53].
According to study reported by (Fahad and Ghafoor, 2012) [96] Different varieties of date fruits having different amount of nutritional information. on an average it gives energy 4600-4795 Kcal/kg, 7.8-9.01% moisture, 3.71-5.47% crude protein, 17.1-23.4% crude fibre, 4.6-7.9% crude oil, 1.03-1.26% ash and 78.03-79.94mg/ml antioxidant activity, 3.13-3.66gm/kg glucose, 3.40-4.2gm/100kg fructose, 3.10-4.12 gm/100kg raffinose, 3.6-3.96 gm/100kg stachyose, 3.06-4.1 gm/100kg sucrose, 1.97-2.56 gm/100kg galactose, 17.9-23.5% lauric acid, 9.7-11% palmitic acid, 2.1-2.7% stearic acid, 40.5-45.7% oleic acid, 7.03-9.2% linoleic acid, 0.11-0.26% linolenic acid, 0.02-0.09% arachidic acid and minerals like 207-688 mg/kg calcium, 738-893 mg/kg magnesium, 3682-4212 mg/kg potassium, 2101-3.63mg/kg phosphorous, 24.8-37.7 mg/kg iron, 8.4-12.7 mg/kg zinc, 3.4-8.4 mg/kg copper, 3.3-7.7 mg/kg manganese, 5.2-6.2 mg/kg boron, 1.2-2.19 mg/kg chromium.
(Bentrad and Ferhat, 2020) [88, 104] Date fruits not only have good amounts of nutrients but also used in the several medical problems like hemorrhoids, constipation, jaundice, cold, sore throat, diarrhea, tonsillitis, rheumatic pains, bronchial asthma.

Tamarind (*Tamarindus Indica*): Tamarind is and important fruit of arid zone belongs to Fabaceae family. The origination place of this fruit is India. The history of the cultivation of tamarind has reported from ancient period. The name tamarind derived from Arabic word tamar-u'l-hind (dark brown pulp of fruit similar to dry dates) and hence named as Tamere-Hindi. At present the cultivation of this fruit in 54 countries around the world.
The edible portion of this fruit is pulp. Flowers with red, yellow and elongated (2.5cm wide). Fruit is bulged and irregularly curved with 12-15cm long. Pods are brown colour and pulp is acidic. (Hemshekhar, Kemparaju *et al*, 2011) [27]. It is called with different names in different languages Teteli in Assam, Ambli in Gujrat and Bengal, Tamarind in English, Imli in Hindi, Amlam in Malayalam, Tentuli in Oriya, Ambilam in Tamil, Chinta in Telugu, Titri in Nephal (Pal, Mukherjee *et al*., 2020)
Timber from the tree used as fuel wood. India is leading producer of tamarind but now Thailand became the major producer of sweet variety tamarind (Hiwale, 2015) [28]. Seed kernel oil is in golden yellow colour. Most valuable part of the ripen fruit is pulp (30-50%) Seeds are 1-10 in number per pod and each ranges 3-10-1.3cm (Hiwale, 2015) [28]. Tree can grow of 12-18meters (under favourable conditions 24-30m). It is highly resistant to drought and aerosol (wind borne salt). One tree can produce 15kg fruits per year. Many tamarind products like fresh pulp, dried pulp, kernel powder, have a great value in foreign countries due to their medicinal value of seeds, leaves, and twigs. (Toungos, 2019) [26]. Presence of tannins and colouring mater on the testa the seed is inedible. The seed extract can be treatment of snakebite, diabetes, jaundice, boils, ulcers and also used in moisturizers, gels, masks, serums. A sweet variety of tamarind used to be grown in Thailand for edible purpose (Hemshekhar *et al*, 2011) [27].
As per (Yadav, Ajay *et al*., 2021) tamarind fruit is filled with 50% of pulp, and 25-40% seed and 11-30% shell. The fruit pulp is good source of protein 3-3.1gm/100gm, Fibre 5.4-5.6 gm/100gm, carbohydrates 67-67.4 gm/100gm, calcium 35-170 mg/100gm, phosphorous 54-110 mg/100gm, iron 1.3-10.9 mg/100gm, sodium 22-24 mg/100gm, potassium 370-375 mg/100gm, vitamins like Thiamine 0.1-0.16 mg/100gm, riboflavin 0.05-0.07 mg/100gm, niacin 0.6-0.7 mg/100gm, ascorbic acid 0.7-3.0 mg/100gm, tartaric acid 8-23.8 mg/100gm.
(Singh, Brailson *et al*., 2021) 100grams of tamarind edible portion contains different nutrients like water 17.8-35.8gm, protein 2-3gm, fat 0.5-0.6hm, carbohydrates 41.1-61.4gm, fiber 2.9gm, Ash 2.6-3.9gm calcium 34-94mg, phosphorous 34-78mg, iron 0.2-0.9mg, Thiamin 0.33mg, Riboflavin 0.1mg, Niacin1mg, vitamin C 44mg, total soluble solids 54-70%, pectin 2.4%, invert sugar 38.2%. All these nutrient content is different from fresh pulp and dried pulp. Amount of nutrients in dried pulp is 15-30% moisture, 2-8.7% proteins, 0.5-2.5% fat,56-70% carbohydrates, 8-18% tartartic acid, 2-2.9% ash, 2-4% pectin, 25-45% reducing sugars, 16% non-reducing sugars, 5.7% starch, 600mg tannins, 33mg/100gm ascorbic acid, 0.18mg thiamine, 0.07-0.09mg riboflavin, 0.6mg niacin.
According to (Devi, Barsha *et al*., 2020) the fruit itself is used for making different kinds of foods like candies, chutneys, sauce, juice, dried fruit block, tamarind pulp powder, pickles. It is also used for different kinds of health benefits like

controlling heart rate and blood pressure, lowering bad cholesterol levels, bronchitis, sore throats, conjunctivitis, killing intestinal worms, per (Yadav, Ajay *et al*., 2021) study tells not only the pulp used for medicinal purpose, but most parts of the tree also used for treating diseases. Tamarind tree bark decoction is used in treatment of asthma, leaf decoction is used for throat infection, cough, fever. The pulp is used in treatment of scurvy.

Bael (*Aegle marmelos*): Bael fruit belongs to Rutaceae Family (Singh *et al*., 2021). Rutaceae family comprise 1900 species and 160 genera (Kishore *et al*., 2017). Tree can grow in altitude 1200msl (Western Himalayas 4000ft altitude (Jana *et al*., 2014). It is called with different names in different regions Bel in hindi, shivaphala in Sanskrit, bael / golden apple in urdu, Bel in Assam and Marathi, Bilivaohal in Gujarat, Marredy in Malayalam, belo in Oriya, vilvama in Tamil, bilva pandu in Telugu, Bil in Punjab (Singh *et al*., 2021). It is native to Indian subcontinent. It is a sacred fruit and used in worship of lord shiva and vinayaka. (Singh *et al*, 2021). Hindus treat this fruit in prayers of lord shiva and parvathi so it is known as "Shiaduma" (Singh, Saroj *et al*, 2019) [46].

Fruit is mainly cultivated in arid and semiarid regions. It is used in ayurveda, unani, for it medicinal and nutraceutical properties. Ripen fruit is sweet, easily palatable. Fruit diseases are treated from the extraction of leaves, fruits, seeds. Each fruit weighs 0.5-2kg depend on varieties genera (Kishore *et al*., 2017). Stem is short, thick, soft, spiny sometimes. Bark is yellowish brown colour. Presence of gummy substance act as adhesive and used in water paints (Singh *et al*, 2019). Fruit is used to cure jaundice, control blood pressure, skin and hair diseases. Juice extracts is used for the removal of toxins present in the body. Bael leaves used to control diabetes diseases. Tree grows up to 6-7.5m height (20-30ft (Singh *et al*, 2019). Flowering occur in form of 4-15 clusters and bloom in May-June. Fruit is spherical, green colour. Pulp is yellow, soft, sweet (Singh *et al*, 2021).

(Rao *et al*, 2011) has reported the nutritional composition of bael seed meal and bael seed protein concentrate. 100 grams of bael seed meal contains 3.7-3.8g/100g moisture, 7.7-7.8 g/100g total ash, 37.6-38.8 g/100g crude fat, 34.7-35.1 g/100g crude protein, 4.7- g/100g crude fibre, 11.6-12.1 g/100g carbohyderaates, 62-62.8 mg/100g calcium, 0.6 mg/100g copper, 1.-1.9 mg/100g iron, 1.1-1.4 magnesium, 295-296.3 mg/100g phosphorous, 4.1-4, mg/100g potassium, 1.8-2.2 mg/100g zinc, 367-367.7 mg/100g total polyphenol, 20.4% palmatic acid, 0.3% palmitoleic acid, 4% stearic acid, 30.7% oleic acid, 24.3% linoleicacid, 19.9% linolenic acid, 0.3% eicosanoicacid, 0.1% eicosamonoeic acid. While 100 grams of bael seed protein meal contains 6.1-6.2 g/100g moisture, 5.2-5.5 g/100g total ash, 1.-1.9 g/100g crude fibre, 16-16.7 g/100g carbohydrates, 90-90.6 mg/100g calcium, 2.4-2.8 mg/100g copper, 4.8-5.2 mg/100g iron, 1-1.5 mg/100g magnesium, 394-395.2 mg/100g phosphorous, 7.5-8.1 mg/100g potassium, 2.3-2.6 mg/100g zinc, 74-745.4 mg/100g total polyphenols, 70.8 g/100g crude protein in which 3.29 g/100g alanine, 10.46 g/100g arginine, 7.54 g/100g aspartic acid, 1.54 g/100g cysteine, 17.9 g/100g glutamic acid, 4.18 g/100g glycine, 1.71 g/100g histidine, 3.17 g/100g isoleucine, 5.97 g/100g leucine, 1.97 g/100g lysine, 1.23 g/100g methionine, 4.03 g/100g phenylalnine, 6.10 g/100g proline, 3.44 g/100g serine, 2.61 g/100g threonine, 3.29 g/100g tyrosine, 3.67 g/100g valine.

(Zehra *et al*, 2015) [3] done a comparative study on Nutritional exploration of leaves, seed and fruit of bael. According to the data of nutritional composition of bael leaves, fruit pulp and seed was analyzed. Proximate composition of bael leaves contains 71.2-72.7% moisture, 0.07% crude fat, 0.98-1.02 ash, 1.09-1.12% protein, 1-1.06% crude fibre, 24.96-24.8 total carbohydrates, 1.5-18.7brix total soluble solids, 4.84-5.1 mg/100g vitamin C, 0.03 mg/100g vitamin B1, 0.02 mg/100g vitamin B2, 0.17-0.19 mg/100g vitamin B3, and aminoacids 2.86% threonine, 3.81% valine, 3.81% methionine, 2.86% isoleucine, 14.29% leucine, 9.53% tyrosine +phenylalanine, 5.71% lysine, 0.95% histidine, 9.52% aspartic acid, 4.76% serine, 8.57% glutamic acid. Beal seed contains 53.7-55.7% moisture,14.94% crude fat, 1.5-2.2% ash, 9.75-0.9 crude protein, 1-1.10% crude fiber, 18.8% carbohydrates, 13.2-14.2 brix total soluble solids, 3.3-3.4mg/100g vitamin C, 0.77 mg/100g vitamin B1, 0.2-0.27 mg/100g vitamin B2, 1.4-1.5 mg/100g vitamin B3, 2.16% threonine, 3.37% valine, 4.57 methionine, 4.09% isoleucine, 16.47% leucine, 2.52% lysine, 1.32% histidine, 11.18% aspartic acid, 2.52% serine, 9.38% glutamic acid and bael fruit pulp contains 63.04-66.1% moisture, 0.28% crude fat, 1.29% ash, 1.87% crude protein, 2.78% crude fiber, 34.35-35.35% carbohydrates, 26.2-27.4 brix total soluble solids, 73.2-75.3 mg/100g vitamin C, 0.16 mg/100g vitamin B1, 0.18 mg/100g vitamin B2, 0.87 mg/100g vitamin B3, 1.82% threonine, 1.82% valine, 6.36% methionine, 2.73% isoleucine, 20.91% leucine, 2.73% lysine, 2.73% histidine, 24.55% aspartic acid, 2.73% serine, 5.45% glutamic acid.

(Fazal and Baliga *et al*, 2011) [4] nutritional value of bael pulp without seeds contains 64.2 g/100g water, 31.8 g/100g fiber, 1.8 g/100g protein, 31.8 g/100g carbohydrate, 0.3 g/100g fat, 0.05mg/100g vitamin A, 1.2 mg/100g vitamin B2, 8.0 mg/100g vitamin C, 0.03 mg/100g thiamin, 55 mg/100g beta carotene, minerals like 85 mg/100g calcium, 31.8 mg/100g phosphorous, 0.6 mg/100g iron, 600 mg/100g potassium,0.21 mg/100g copper.

Jamun (*Syzygium cuminii*): Jamun is one of the underutilized fruit in India. it belongs to family Myrtaceae. Common name for Jamun are Black plum, Indian blackberry, java plum. Many people in Gujarat treat this fruit as "Fruit of gods". It grows up to 1600msl altitude and up to 30meters height. Jamun tree produce white flowers in clusters at tip of stems. Actual yield will comes after 10 years if the crop is grown by seed, whereas by vegetatie propagation 5-6years (Madani *et al*., 2021). Fruit is in elepsoid/ oval/ round shape and purplish color and blackish pink color pulp. Jamun fruits are of two types a) Raj jamun b) Kaatha. Pulp of raj jamun is sweet and grayish/ blakish pink color with small stone (seed) while kaatha has small fruits and big sized seed. It can be eaten as fresh and also in the form of juice, jam squashes. Alkaloid present in the seeds help in controlling blood sugar level (stop converting of starch to sugar). Tree is tolerant to sodic and saline soils (Singh *et al*., 2019). jamun is one of the arid region fruit which contains of different amount of nutritional content in seeds and fruit pulp. It is rich source of anthocyanin. Flowering starts from January and yield can be harvested from May-June. It is non climatric fruit which cannot ripen after harvesting (Lawande *et al*., 2014)

Jamun pulp contains of 79.21-81.4 moisture on wet basis, 1-1.08% ash, 14.6-16.2 brix total soluble solids, 97.59% total

carbohydrate, 7.88% total sugar, 4.7-4.8% pectin, 0.18-0.2% fat, 0.65-0.68% protein, 49.7-51.8 mg/100g ascorbic acid, 203.-211.4mg/g polyphenol, 94.5-104.19mg/100g tannin, 0.53% fibre, 195.15-201.1mg/100g anthocyanin, (Ghosh *et al.*, 2017) [5] and minerals like 11.7-11.8 mg/100g sodium, 172.4-189.6 mg/100g potassium, 81.4-92.5 mg/100g calcium, 0.46 mg/100g zinc, 4.66-5.2 mg/100g iron, 27.1-30.5 mg/100g magnesium, 1.8-2.2 mg/100g copper, 0.2 mg/100g manganese,1.06-1.19mg/100g chromium. Jamun seed contains of 52.2-55.% moisture (wet basis), 3.13-3.19% ash, 1.4-1.5 brix total soluble solids, 89.6-89.9% total carbohydrate, 5.5-6.1% total sugar, 1.28-1.39% fat, 4.6-4.9 protein, 1.84mg/100mg ascorbic acid, 386-397.7mg GAE/g polyphenol, 388.9-396.7 mg/100g tannins, 1.21-1.26% fibre and minerals 43.8-55.89 mg/100g sodium, 606.4-674.8 mg/100g potassium, 13.8-161.6 mg/100g calcium, 0.46-0.51 mg/100g zinc, 4.2-5 mg/100g iron, 11.6-119.66 mg/100g magnesium, 2.13-2.17 mg/100g copper, 0.4-0. mg/100g manganese, 1.4-2.1 mg/100g chromium. (Nayik and Gull., 2020)

(Joshi, Sharma *et al*., 2012)jamun fruit contains of 16 brix total soluble solids, 1.19% acidity, 12.4% total sugar, 8.6% reducing sugars, 2.73% non-reducing sugars, 6.4gm fresh weight, 2.2gm seed weight, 4.2gm pilp weight,seed to pulp ratio is 1:1.90, 81.3% moisture, 0.29% crude fat, 1.26% crude protein, 0.8% ash, 1.05% crude fiber, 15.2% carbohydrate, 21.48mg/100g ascorbic acid, 185.3mg/100g anthocyanins, 168.2mg/100g total tannin, 2.13g/100g total phenols, 95.8 antioxidant activity. The fruit contains pharmacological properties like antiinflamatory, anti-fungal, antiviral, hypoglycemic and antidiabetic effects (mostly seed powder is used) (Tarai *et al.*, 2019) [17]. Due to rich nectar flowers it is used by bee keepers, seeds used as natural healing compounds, bark used as a brown dye, wood used as charcoal, fruit for consumption (Madani *et al.*, 2021) [19].

Phalsa (*Grewia asitica*): The fruit belongs to Tiliaceae family. it is a bushy plant and tolerate temperature 45celcius and freezing temperature. Grewia genus contains 150 species out of which 40 species grown in India. It is native to India. It can grow on mountains up to 3000 feet (914m). Mostly it is cultivated in tropical and subtropical areas of india. It is called with different names in different languages Shunkri in bengali, phulsa in kannada, phutiki in telugu, unnu in tamil, shukri in gujarati, chadicha in malayalam. It yields 6-7kg fruits per plant (Krishan, Singh *et al*., 2018).

Fruit is in deep reddish brown colour with yellow colour flowers and produced in cymose inflorasence. One of the species G. tenax is drought resistant. It is treated for heart, fever, diarrhea (unani medicine). Punjab, Haryana, Rajasthan, Madhya Pradesh, Uttar Pradesh states commercially grow this fruit in India (Kumar *et al.*, 2014). It is rich source of bio active compounds slike tannins, phenols, flavonoids, anthocyanins. (Khan *et al*., 2019).

(Sinha *et al.*, 2015) studied different parameters of tall and dwarf varieties of phalsa where tall varieties of phalsa fruit contains 91.3% edible portion, 8.7% seed and 67.5% juice yield. The nutritional composition of edible portion of tall varieties are 76.8% moisture, 5.73% total sugars (1.2% reducing sugars, 4.49% non-reducing sugars), 1.48% titrable acidity, 3.13% fruit protein, 8.75% seed protein, 1.40% pulp protein while the dwarf varieties contains approximately 90.79% edible portion, 9.21% seed, 65.90% juice yield, 74.83% moisture, 7.95% total sugars (0.99% reducing, 6.96% noon reducing sugars) 1.12% titrable acidity, 1.89% fruit protein, 7% seed and pulp peotein. 100grams of fruit contains 1.57g/100g protein, ≤0.1 g/100g fat, 21.1 g/100g carbohydrate, 1.1 g/100g ash, 5.53- 5.55g/100g fibre, and minerals like 136mg/100g calcium, 1.08-1.40 mg/100g iron, 0.99 mg/100g cobalt, 0.48-1.08 mg/100g chromium, 0.48 mg/100g copper, 2.61 mg/100g nickel, 144 mg/100g zinc, 24.2 mg/100g phosphorous, 17-17.3 mg/100g sodium, vitamins like 0.02 mg/100g vitamin B1, 0.825 mg/100g vitamin B3, 4.38 mg/100g vitamin C, 0.264 mg/100g vitamin B2, 16.11 mg/100g vitamin A (Mehmood *et al*, 2020) [6].

(Suliman, *et al*, 2018) [8] Chemical composition of phalsa seed contains 0.54-0.56% titratable acidity, 12.88-15.2 µg/g gallic acid, 18.06-22.6 µg/g protochatchuic acid, 19.17-25.21 µg/g catachine, 15.19-17.34 µg/g syrngic acid, 24.7-30.3 µg/g vanillic acid, 5.61-6.8 µg/g coumarin, 4.91-6.05 µg/g cinnamic acid, 19.87-26.1 µg/g chyrsin, 11.98-14.23 caffeic acid, 16.84-24.49 µg/g ferulic acid, 4.28-5.3 µg/g sinapic acid, 3.98-4.1 µg/g rutin, 9.89 µg/g kaempferol, 3.25-3.29 mg/g total phenol content, 33.5-33.8 µg/g lutein, 26-26.19 µg/g beta carotene.

(Khan *et al*., 2019) study reported that, the amount of amino acids present in phalsa seed are 8.01% isoleucine, 11.02% leucine, 2% lysine, 2.08% methionine, 7% phenylaniline, 4.06% threonine, 1% tryptophan, 13.02% valine, 2.0 arginine, 2.02% histidine, 1.03% alanine, 19.06% aspartic acid, 1.0% cystine, 11.0% glutamic acid, 1.02% glycine, 3.01% proline, 4.02% serine, 3% tyrosine, 651.3-659.4 mg/100g alpha tocopherol, 5.01-5.03mg/100g beta tocopherol, 1.08-1.22mg/100g gama tocopherol, 3.99-4.1 mg/100g campsterol, 4.04-4.08 mg/100g betasterol, 2.91-3.1 mg/100g fukosterol, 18.3-20.1 mg/100g beta sitosterol, 0.24-0.4 mg/100g gramisterol, 1.02-1.22 mg/100g cycloartenol, 0.48-0.72 mg/100g avenasterol.

Phalsa juice is said to have a colling effect in hot summers. Leaves are used for skin eruptions due to its antibiotic action, bark is used as a substitute of soap in some areas (Burma). Fibre from bark used for rope making and the tree bark used in making archer's bow, poles. The fruit can be consumed as fresh or by making dessers, soft drinks and juices (Mishra *et al.*, 2014).

Karonda (*Carissa carandas*): Fruit belongs to Apocynaceae family. In tamil it is called as Kalakka, Karmardaka in Sanskrit, Karomcha in Bengali, christ's thorn in south India, vakkay in Telugu, karja tenga in Assam (Singh and Uppal, 2015) [35] namdeng in Thailand, caramba in Caranda, caraundaand perunkila in phillipines (Devmurari *et al*, 2009) [36]. Naturally it can grow up to 1800msl. It is an evergreen shrub (up to 3m) with yellowish brown colour bark, leaves are opposite, oval/ elliptic shape(2.5-7.5cm) fruit is berry type and elepsoid shape, red colour in turning stage and turns to dark purple when ripe (occur in clusters of 3-10 fruits) and presence of 8 seeds (small, flat, brown (Devmurari *et al*, 2009) [36]. Blooming from February- march. Fruit is simple succulent, fleshy, globular, size range from 14-18mm. The plant well suitable to home garden because of its bushy nature (Arif *et al*, 2016) [37].

It is used in medicine like unani, ayureda, homeopathy. It is treated against scabies, intestinal worms, diarrhea. It is treated against anemia due to rich in iron content. Ripe fruit is acidic and used to treat ulcer, skin disorders (Jayakumar and

Muthuraman, 2018) [34]. Whole plant is used in medicine, fruits to treat liver dysfunction, leaf decotion for fever, ear ache, roots for itches, insect repellent. Haresting done at different stages like immature stage for vegetable purpose and ripen for consuming fresh and juice preparation. Plant process wide range of phytochemicals used in medicine to treat against anti-diabetic activity, anti-inflammatory, anti-pyretic, hepatoprotective anti-ulcer, cardiovascular activity (Singh and Uppal, 2015). Fruits area stringent and sour taste (Dalal *et al*, 2010) [12]. Leaves are used as fodder for tusser silk worm (Devmurari *et al*, 2009) [36]. When fruit is cooked it release gummy latex. Fruit and root bark grounded to powder and taken with water cures piles. Root is mixed with horse urine, lime juice for itching (Arif *et al*, 2016) [37].

According to study reported by (Chauhan *et al*, 2015) [11] Fresh karonda fruit contains 81.5-82.9% moisture, 2.46-2.6% ash, 18.66-18.91% carbohydrates, 1.3% fat, 2.07-4.11% protein, 25.4% neutral detergent fiber, 16.03-16.0% acid detergent fiber, 9.4-9.9% hemicelluloses, 14.0% cellulose, 3.1-3.1% lignin, 5.3-5.5mg TAE/g total phenolic content, 0.44mg E/100g total flavonoid content, 34.4-36.2% DPPH(2,2-diphenyl-1-picrylhydrazyl), 58.6% FRAP (ferric reducing scavenging activity), 0.98g/100g tannins, 1.94g/100g alkaloid, 54.03g/100g anthocyanin, 29-29.57mg/100g calcium, 3.45mg/100g iron, 32.1mg/100g phosphorous.

As per study reported by (Dalal *et al*, 2010) [12] chemical composition of mature and fresh karonda. Mature karonda fruit contains 89.82% edible portion, 10.18 seed part, 88.7 moisture, 6.76 brix total soluble solids, 3.94% acidity, 6.98 mg/100g ascorbic acid, 3.96% total sugars, 3.15% reducing sugars, 2.82% crude protein, 6.24mg/100g iron, 16.32mg/100g calcium, 24.74mg/100g phosphorous. While the ripen karonda fruit contains 91.72% edible portion, 8.28% seed part, 85.97% moisture, 7.8brix total soluble solids, 1.51% acidity, 3.79mg/100g ascorbic acid, 5.28% total sugars, 4.15% reducing sugars, 2.96% crude protein, 6.88mg/100g iron, 11.55mg/100g calcium, 24.15mg/100g phosphorous.

(Azeez *et al*, 2016) [10] studied nutritional information of different varieties of karonda fruit. Konkan bold one of the variety contains 83.2% fruit pulp, 12.8 total soluble solids, 2.22 acidity, 19747µg/gm vanillic acid, 3654.6µg/gm protocatechuic acid, 976.5µg/gm t-cinnamic acid, 498.5µg/gm chlorogenic acid, 492.1µg/gm 2,4- dihydroxybenzoic acid, 385.1µg/gm syringic acid, 311.17µg/gm salicylic acid, 144.4µg/gm caffeic aid, 100.34 gentisic acid, 1.7µg/gm p-hydroybenzoic acid, 3.23µg/gm coumaric acid, 31.76 gallic acid, and flavonoids like 8296.07µg/gm rutin, 2473.9 myricetin, 255.3µg/gm umbelliferone, 104.27µg/gm catechin, 61.5µg/gm quercetin, 22.3µg/gm hesperetin, 30.03 µg/gm naringenin, 16.51µg/gm luteolin, 1.98µg/gm apigenin.

It can be eaten fresh or by making pickels, preseres, juice, jelly etc. (Singh and Uppal, 2015).

Different types of drying: Drying is one of the oldest preservation processes available since prehistoric times. The main feature of this process is to reduce the water content in order to slow down the food spoilage by microorganism. common words found are “drying” or “dehydration”, or “dewatering” (Ahmed *et al*., 2013). Throughout history, sun, wind, and smoldering fire have been used to extract water from fruits, flesh, fish, and other matter. According to the definition, dehydration is a way of removing water from food by passing hot air through it, which inhibits the growth of enzymes and bacteria (Hasan *et al*., 2019).

Sun Drying

It is the simple and oldest way of drying. Hot and dry days are best for sun drying. On average the temperature in the summer season is higher than in the winter season. Minimum temperature of 35 ˚C-45 ˚C is needed or higher temperatures will do better. It takes several days to dry foods. The temperature of sun drying is uncontrollable so it can be risky (Ahmed *et al*., 2013)

Solar Drying

The objective of a solar dryer is to provide the required amount of heat i.e. more than ambient heat under given humidity. It increases the vapor pressure of the moisture within the product and decreases the relative humidity of the drying air so that the moisture carrying capacity of the air can be increased. Air is drawn through the dryer by natural convection or by a fan. Solar systems are renewable, economical, and easy to operate (Ahmed *et al*., 2013).

Freeze drying

This method is mainly used for the drying of unstable materials. It works on the principle of sublimation. This process is divided into three steps (Freezing, Primary drying, and secondary drying). Freeze-drying is also known as lyophilization. This process works by freezing the material and then allow the frozen water in the material to the gas phase (sublimation- solid phase to gas) (Nemzer *et al*., 2018).

Osmotic Drying: (Chandra *et al*., 2015) reported. The principle of osmotic drying is that water diffuses from low concentration (Hypotonic solution) to high concentration solution (Hypertonic solution) through a semi-permeable membrane till equilibrium is established.

Vacuum Drying: Dehydration through the vacuum drying technique is done for highly perishable commodities. It has a higher rate of drying, lower temperature, better retention, and less usage of energy, and it also facilitates the better retention of product color, taste, and other contents such as vitamins and volatile aroma (Sagar and Kumar, 2010). in the system, the lower pressure (vacuum) lows the drying at low temperature which results in reduced final moisture of the product similar to other methods of drying.

Fluidised bed drying: In this system the air is allowed to flow through a bed of solid material with a greater velocity, the solid particle becomes blown up and become suspended in the air stream. At this stage, solid particle looks like a boiling stage, hence this stage is called a fluidized state (Senapati *et al*., 2021). Fluidization is done by suspending solid particles on a fast-moving air stream and Bed Refers to the layer of suspended solid molecules (which holds the sample to be dried) and Dryer Equipment. It’s the equipment where wet food products are dried (Kumar *et al*., 2015).

Oven drying: It is faster than sun drying. But oven drying can be used only on a small amounts. An ordinary kitchen oven can hold only 3-4kg of food at one time. Set the oven on the lowest possible setting and preheat to 60℃. Do not use the

broiler unit of an electric oven due to fast drying rate on top trays because these are nearer to heat source (Zhang *et al*., 2017).

Effect of drying on nutritional information of fruits: Heat and oxygen sensitive phenols and ascorbic acid. It is shown that more retention of phenols, antioxidant and colour in vacuum microwave drying at 240W. Freeze drying retains more antioxidants than other drying process (Wojdylo *et al.*, 2009). While (Sultana *et al.*, 2012) study tells that more retention of total phenols and antioxidant activity at optimum temperature of oven drying than ambient drying (sun). (Madrau *et al.*, 2009) [56] phenols and antioxidants don't show same in different drying methods. Higher temperature might give good product but not from nutrition point of view (less antioxidant and phenols). Oven dried fig fruits shows rich amount of vitamin C while sugars and organic acids are significant in fresh and dried fig fruits i.e. more sugars and organic acids than phenols are in fresh and dried fruits (Slatnar *et al.*, 2011) [57]. Higher temperatures during drying can damage cell wall and release phenolic compounds and increase shelf life by protecting from oxidative degradation and decrease in phenols and flavonoids in dried fruit (Vidinamo *et al.*, 2020) [58]. Total phenolic compounds of avocado pulp (ripe) increased on different drying process (Alkaltham *et al.*, 2021) [59]. Freeze dried ber fruit retained total phenolic compounds while thermal drying showed decrease in antioxidant activity and total phenols. Microwave ber fruit shows high phenols (individual i.e. epicatechin, catechin, ruitn, cinnamic acid) (Gao *et al.*, 2012) [60]. It is showed that more retention of phenols, tannins, flaonoids in pomegranate peel (Catechin, epicatechin, hesperidin, rutin) when subjected to freeze drying (Mphahlele *et al.*, 2016) [61]. Temperature is one of the most important parameter for nutrient retention or degredation. Combination of traditional and new drying methods can improve retention of nutrients than fresh fruits (Santos and Silva, 2008) [62]. Increase in drying temperature can decrease total phenolic compounds and antioxidant activity (Shahdadi *et al*, 2013) [64]. Osmotic drying can decrease weight of fruit and increase sucrose concentration (Arballo *et al*, 2012) [63].

Table 1: Effect of different drying methods on nutritional composition of arid zone fruits

Method of drying	Fruit	Effect	References
Solar/ hot air oven	Aonla (shreds)	Decreased Ascorbic acid and increased tannins, acidity, reducing and non-reducing sugars of aonla	Prajapati *et al.*, 2011 [65]
Microwave convective drying	Jamun (pulp)	More retention of total phenolic content, antioxidant activity, manomeric anthocyanin activity.	Paul *et al.*, 2018 [66]
Vaccum drying, freeze drying	Jamun (pulp)	Less retention of total phenolic content, antioxidant activity, manomeric anthocyanin activity.	Paul *et al.*, 2018 [66]
Hot air drying	Pomegranate (arils)	More total soluble solids, more increase of total phenolic content and total anthocyanin content reduction in radical scavenging activity	Adetoro *et al.*, 2020
Freeze drying	Pomegranate (arils)	More reduction of radical scavenging activity, decreased total soluble solids	Adetoro *et al.*, 2020
Sun drying	Ber	Increased vitamin C, total phenolic content, antioxidant capacity, antioxidant activity.	Anjum *et al.*, 2020 [67]
Oven drying	Ber	Increased vitamin C, total phenolic content, antioxidant activity and negative effect on antioxidant capacity.	Anjum *et al.*, 2020 [67]
Open air sun drying	Date palm	Decreased DPPH activity, total phenolic content, total flavonoid content.	Mechlouch *et al.*, 2015 [105]
Microwave drying	Date palm	Increase in flavonoid andpolyphenol content, ABTS radical scavenging activity, DPPH activity	Mechlouch *et al.*, 2015 [105]
Direct solar drying	Date palm	Decreased DPPH activity, total phenolic content, total flavonoid content.	Mechlouch *et al.*, 2015 [105]
Fluidised bed drying	Aonla	Increased ascorbic acid, decreased tannin content	Pareek and Kaushik, 2012 [68]
Hot air drying	Ber	Decreased phenolic content	Elmas *et al.*, 2018 [69]
Infrared drying (50 degree)	pomegranate	Increased phenolic content	Briki *et al.*, 2019 [70]
Spray drying	Tamarind	Decreased total phenolic content	Muzaffar *et al.*, 2016 [71]
Spray drying	Tamarind (pulp powder)	Increased total phenolic content and antioxidant activity.	Shridhar *et al*., 2014 [72]
Spray drying	Jamun (pulp powder)	Increased total phenolic content and total antioxidant capacity	Singh *et al.*, 2019
Spray drying (gum Arabica)	Jamun	Increased phytochemical properties like total anthocyanins, total flavonoid content, total phenolic activity.	Raman *et al.*, 2020 [74]
Freeze drying	Combination of pear and jamun (powder, juice)	Increased anthocyanins, phenolic content, Antioxidant activity.	Kapoor *et al.*, 2016 [75]
Freeze drying	Bael (pulp)	No chance in protein, fat, carbohydrate, mineral, slight change in phenolic content, no effect on (DPPH) activity.	Hazra *et al.*, 2019 [76]
Microwave drying	Bael (pulp)	Increased in polyphenols than fresh pulp	Hazra *et al.*, 2020 [77]
Sun drying	Bael (pulp)	Decreased polyphenols and increased tocopherols	Hazra *et al.*, 2020 [77]
Hot air drying	Bael (pulp)	Increased in vitamin content (B1, B5) (γ-carotene) content	Hazra *et al.*, 2020 [77]
Freeze drying	Bael (pulp)	Maimum retention of nutrients	Hazra *et al.*, 2020 [77]

Conclusion

It has been seen that different kinds of drying methods affect the different nutritional components in the fruits. Present investigation was studied, and observed that different nutrients retain more or less in different drying methods. Study was observed on different kinds of fruits and different forms like fruit pulp, fruit powder, fruit meal, seed meal. Most of the nutrition affected on phenolic compounds, flavonoids, physico-chemical characteristics. It has been observed that freeze drying shows better retention of flavonoids, phenolic compounds and also observed that the nutrients which are susceptible to heat gets more degradation. Different advantages and disadvantages also observed on different drying techniques. For example, there is huge amount of sunlight which is freely available in nature which is used for one of the oldest method of drying, but in the same time the disadvantage is that we cannot control the temperature to the desirable and also availability of sunlight is less in winters in some areas (cold arid regions). In the same time if final output is retention of vitamin C which is heat sensitive, low temperature drying method is recommended for such types of nutrients.

References

1. Pareek, Sunil. Nutritional composition of jujube fruit." Emirates Journal of Food and Agriculture, 2013, 463-470.
2. Rao, Galla Narsing, Karakala Balaswamy, Pamidighantam Prabhakara Rao, Dubasi Govardhana Rao, Akula Satyanarayana *et al*. Nutritional quality, fatty acids, amino acids and functional characteristics of bael (*Aegle marmelos* L.) seed protein concentrate. Journal of Food and Drug Analysis. 2011;19(4):528-542.
3. Lakht-e-Zehra, Asadullah, Nabeela Dar G, Nida Saleem, Umed Ali Soomro, Waqas Afzal *et al*. Nutritional exploration of leaves, seed and fruit of bael (*Aegle marmelos* L.) grown in Karachi region. Pak. J. Biochem. Mol. Biol. 2015;48(3):61-65.
4. Baliga, Manjeshwar Shrinath, Harshith Bhat P, Nandhini Joseph, Farhan Fazal. Phytochemistry and medicinal uses of the bael fruit (*Aegle marmelos* Correa): A concise review. Food Research International. 2011;44(7):1768-1775.
5. Ghosh, Payel, Rama Chandra Pradhan, Sabyasachi Mishra, Avinash Singh Patel, Abhijit Kar. Physicochemical and nutritional characterization of jamun (*Syzygium cuminii*). Current Research in Nutrition and Food Science Journal. 2017;5(1):25-35.
6. Mehmood Arshad, Muhammad Ishaq, Muhammad Usman, Lei Zhao, Asad Ullah, Chengtao Wang *et al*. "Nutraceutical perspectives and value addition of phalsa (*Grewia asiatica* L.): A review. Journal of Food Biochemistry. 2020;44(7):e13228.
7. Sinha Jyoti, Shalini Purwar, Satya Kumar Chuhan, Gyanendra Rai. Nutritional and medicinal potential of Grewia subinaequalis DC. (syn. *G. asiatica*.) (Phalsa). Journal of Medicinal Plants Research. 2015;9(19):594-612.
8. Suliman Zahra EA, Nahla Zidan S, Shaden Foudah HI. Chemical compositions, antioxidant, and nutritional properties of the food products of Guddaim (Grewia tenax). International Journal of Pharmaceutical Research & Allied Sciences. 2018;7(3):172-182.
9. Zia-Ul-Haq Muhammad, Shakeel Ahmad, Imran Imran, Sezai Ercisli, Marius Moga. Compositional study and antioxidant capacity of *Grewia asiatica* L. seeds grown in Pakistan. Comptes Rendus Acad. Bulg. Sci. 2015;68:191-200.
10. Azeez Shamina G, Karunakaran PC, Tripathi KS, Shivashankara, Roy TK *et al*. Evaluation of antioxidant activity, total phenolics and phytochemical content of selected varieties of karonda fruits (*Carissa carandas*). Indian J. Agric. Sci. 2016;86(6):815-822.
11. Chauhan Ambika, Beenu Tanwar, Intelli Arneja. Influence of processing on physiochemical, nutritional and phytochemical composition of *Carissa spinarum* (karonda) fruit. Asian Journal of Pharmaceutical and Clinical Research. 2015;8(6):254-259.
12. Dalal RP, Thakur NA, Avtar Singh. Nutritional value of Karonda (*Carissa carandas* Linn). A non-conventional fruit under semi-arid condition of Punjab. Indian J. Agrofor. 2010;12:102-104.
13. Singh AK, Sanjay Singh, Saroj PL. Scientific cultivation of aonal, 2020.
14. Singh AK, Sanjay Singh, Purnima Makwana. Characterization of aonla (*Emblica officinalis*) varieties under zero irrigation semi-arid conditions. Indian Journal of Agricultural Sciences. 2015;85(10):1365-9.
15. Tewari Rishika, Vivek Kumar, Sharma HK. Physical and chemical characteristics of different cultivars of Indian gooseberry (*Emblica officinalis*). Journal of food science and technology. 2019;56(3):1641-1648.
16. Reena Saini, Ram Chander Sihag. Flowering Biology and Phenology of Aonla (*Emblica officinalis* Gaertn.) in the Semi-arid Environment of North-West India. International Journal of Agricultural Research. 2020;15:1-8.
17. Singh Sanjay, Mishra DS, Singh AK, Pradhan S, Tarai RK, Panigrahi I *et al*. Plant Growth Regulators in Jamun (*Syzygium cumini* Skeels). JAYA PUBLISHING HOUSE Publisher and Distributor H-1/60, Sector-16, Rohini, Delhi-110089, 2019.
18. Singh Saurabh, Singh SP, Vaibhav Singh, Kumari Shikha. Studies on floral biology, fruit set and fruit drop of different genotypes of jamun (*Syzygium cumini* Skeels). The Pharma Innovation Journal. 2019;8(1):558-561.
19. Madani Babak, Amin Mirshekari, Elhadi Yahia M, John Golding B, Shokrollah Hajivand, Abdolmajid Mirzaalian Dastjerdy. Jamun (*Syzygium cumini* L. Skeels): A Promising Fruit for the Future. Horticultural Reviews. 2021;48:275-306.
20. Singh Gorakh, Rajneesh Mishra. Aonla Rejuvenation. PFDC, CISH, Lucknow, 2007, 16.
21. Lawande KE, Haldankar PM, Dalvi NV, Parulekar YR. Effect of Pruning on Flowering and Yield of Jamun cv. Konkan Bahadoli. Journal of Plant Studies. 2014;3(1):114.
22. Mishra DS, Rajesh Kumar, Akath Singh. PHALSA.
23. Kumar M, Dwivedi R, Anand AK, Kumar A. Effect of nutrient on physicochemical characteristics of phalsa (*Grewia subinaequalis* DC) fruits. Global Journal of Bio-Science and Biotechnology. 2014;3(3):320-323.
24. Singh Krishan Kumar, Shiv Pratap Singh. Cultivation and utilization in Phalsa (*Grewia asiatica* L.) under Garhwal Himalayas region. Journal of Medicinal Plants Studies.

2018;6(1):254-256.
25. Khan Rao Sanaullah, Waqas Asghar, Nauman Khalid, Wahab Nazir, Muhammad Farooq, Iftikhar Ahmed *et al*. Phalsa (*Grewia asiatica* L.) fruit berry a promising functional food ingredient: a comprehensive review. Journal of Berry Research. 2019;9(2):179-193.
26. Toungos Mohammed D. Tamarind (*Tamarindus indicus* L) Fruit of Potential Value But Underutilized in Nigeria. International Kournal of Innovative Food, Nutrition and Sustainable Agriculture. 2019;7(1):1-10.
27. Hemshekhar Mahadevappa, Kempaiah Kemparaju, Kesturu Subbaiah Girish. Tamarind (*Tamarindus indica*) seeds: an overview on remedial qualities. Nuts and seeds in health and disease prevention, 2011, 1107-1114.
28. Hiwale S. Tamarind (*Tamarindus indica* L.). Sustainable Horticulture in Semiarid Dry Lands, 2015, 197-212.
29. Pal Dilipkumar. Nuts and Seeds in Health and Disease Prevention || Tamarind (*Tamarindus indica*) Seeds in Health and Nutrition, 2020, 171-182.
30. Shahrajabian Mohamad Hesam, Mehdi Khoshkharam, Peiman Zandi, Wenli Sun, Qi Cheng. Jujube, a super-fruit in traditional Chinese medicine, heading for modern pharmacological science. Journal of Medicinal Plants Studies. 2019;7(4):173-178.
31. Wojdyło Aneta, Ángel A. Carbonell-Barrachina, Pilar Legua, and Francisca Hernández. "Phenolic composition, ascorbic acid content, and antioxidant capacity of Spanish jujube (*Ziziphus jujube* Mill.) fruits. Food chemistry. 2016;201:307-314.
32. Hernández FCA, Legua P, Melgarejo P, Martínez R, Martínez JJ. Phenological growth stages of jujube tree (*Ziziphus jujube*): codification and description according to the BBCH scale. Annals of Applied Biology. 2015;166(1):136-142.
33. Dubey Nidhi, Dhriti Solanki, Tara Negi. Knowledge of farm women in cultivation and postharvest practices of ber (*Ziziphus mauritana*) in Bharatpur District. Ind. J. Extn. Educ. & RD. 2013;21:72-78.
34. Jayakumar Kaliyamoorthy, Muthuraman B. Traditional uses and nutrient status of Indian native plant fruit (*Carissa carandas* Linn.). World Scientific News. 2018;96:217-224.
35. Singh Akansha, Gursimran Kaur Uppal. A review on carissa carandas ğ phytochemistry, ethnoğpharmacology, and micropropagation as conservation strategy. Asian J Pharm Clin Res. 2015;8(3):26-30.
36. Devmurari V, Shivanand P, Goyani M, Vaghani S, Jivani N. A review: Carissa congesta: phytochemical constituents, traditional use and pharmacological properties. Pharmacognosy Reviews. 2009;3(6):375.
37. Arif Muhammad, Mehnaz Kamal, Talha Jawaid, Mohammad Khalid, Kuldeep Singh Saini, Arun Kumar *et al*. *Carissa carandas* Linn.(Karonda): An exotic minor plant fruit with immense value in nutraceutical and pharmaceutical industries. Asian J. Biomed. Pharm. Sci. 2016;6(58):14-19.
38. Pareek Sunil, Daniel Valero, María Serrano. Postharvest biology and technology of pomegranate. Journal of the Science of Food and Agriculture. 2015;95(12):2360-2379.
39. Meena Nirmal Kumar, Ram Asrey, Murlimanohar Baghel. Pomegranate cultivation is promising. Indian Farming. 2018;68(06):30-33.
40. Blumenfeld A, Shaya F, Hillel R. Cultivation of pomegranate. Options Méditerranéennes Ser. A. 2000;42:143-147.
41. Chandra Ram K, Dhinesh Babu, Vilas Tejrao Jadhav, Jaime A, Silva TD. Origin, history and domestication of pomegranate. Fruit, Vegetable and Cereal Science and Biotechnology. 2010;2:1-6.
42. Bassiri-Jahromi Shahindokht. *Punica granatum* (Pomegranate) activity in health promotion and cancer prevention. Oncology reviews, 2018, 12(1).
43. Bhardwaj RL, Nandal Urvashi. Nutritional and therapeutic potential of bael (Aegle marmelos Corr.) fruit juice: a review. Nutrition & Food Science. 2015;45(6):895-919.
44. Singh Krishan Kumar, Brahmanand Bairwa, Ravi Kumar Mahour, Vikas Pareek. *Aegle marmelos* (Bael) Benefit for Health: A Review, 2021.
45. Jana BR, Bikash Das, Madhumita Singh. Conservation and performance of some bael (*Aegle marmelos* correa) genotypes under rain-fed ecosystem of eastern India. International Journal of Information Research and Review. 2014;1(10):133-134.
46. Singh AK, Sanjay Singh, Saroj PL, Hare Krishna, Singh RS, Singh RK *et al*. Research status of bael (*Aegle marmelos*) in India: A review. Indian Journal of Agricultural Sciences. 2019;84(10):1563-71.
47. Kishore K, Mahanti KK, Samant D. Phenological growth stages of bael (Aegle marmelos) according to the extended Biologische Bundesantalt, Bundessortenamt und Chemische Industrie scale. Annals of Applied Biology. 2017;170(3):425-433.
48. Tengberg M. Beginnings and early history of date palm garden cultivation in the Middle East, 2012.
49. Pintaud JC, Ludeña B, Aberlenc-Bertossi F, Zehdi S, Gros-Balthazard M, Ivorra S *et al*. Biogeography of the date palm (*Phoenix dactylifera* L., arecaceae): insights on the origin and on the structure of modern diversity. Acta Horticulturae. 2013;(994):19-38.
50. Gros-Balthazard Muriel, Hazzouri Khaled, Flowers Jonathan. Genomic Insights into Date Palm Origins. Genes. 2018;9(10):502.
51. Ghori W, Saba N, Jawaid M, Asim M. A review on date palm (phoenix dactylifera) fibers and its polymer composites. IOP Conference Series: Materials Science and Engineering. 2018;368:012009.
52. Chao ChihCheng T, Krueger Robert R. The Date Palm (*Phoenix dactylifera* L.): Overview of Biology, Uses, and Cultivation. HortScience. 2007;42(5):1077-1082.
53. El-Far Ali H, Oyinloye Babatunji Emmanuel, Sepehrimanesh Masood, Allah Mahmoud Gab A, Reidah Ibrahim Abu, Shaheen Hazem M *et al*. Date Palm (Phoenix dactylifera): Novel Findings and Future Directions for Food and Drug Discovery. Current Drug Discovery Technologies, 2018, 15.
54. Wojdyło Aneta, Figiel Adam, Oszmiański Jan. Effect of Drying Methods with the Application of Vacuum Microwaves on the Bioactive Compounds, Color, and Antioxidant Activity of Strawberry Fruits. Journal of Agricultural and Food Chemistry. 2009;57(4):1337-1343.
55. Bushra Sultana. Effect of drying techniques on the total phenolic contents and antioxidant activity of selected fruits. Journal of Medicinal Plants Research, 2012, 6(1).
56. Monica Madrau A; Amalia Piscopo, Anna Sanguinetti M,

Alessandra Del Caro, Marco Poiana, Flora Romeo V *et al*. Effect of drying temperature on polyphenolic content and antioxidant activity of apricots. 2009;228(3):441-448.
57. Slatnar Ana, Klancar Urska, Stampar Franci, Veberic Robert. Effect of Drying of Figs (Ficus carica L.) on the Contents of Sugars, Organic Acids, and Phenolic Compounds. Journal of Agricultural and Food Chemistry. 2011;59(21):11696-11702.
58. Vidinamo Frank, Fawzia Sabrina, Karim MA. Effect of drying methods and storage with agro-ecological conditions on phytochemicals and antioxidant activity of fruits: a review. Critical Reviews in Food Science and Nutrition, 2020, 1-9.
59. Alkaltham MS, Uslu N, Özcan MM, Salamatullah AM, Mohamed Ahmed IA, Hayat K *et al*. Effect of drying process on oil, phenolic composition and antioxidant activity of avocado (cv. Hass) fruits harvested at two different maturity stages. LWT. 2021;148:111716.
60. Gao Qing-Han, Wu Chun-Sen, Wang Min, Xu Bian-Na, Du Li-Juan. Effect of Drying of Jujubes (*Ziziphus jujuba* Mill.) on the Contents of Sugars, Organic Acids, α-Tocopherol, β-Carotene, and Phenolic Compounds. Journal of Agricultural and Food Chemistry. 2012;60(38):9642-9648.
61. Mphahlele Rebogile R, Fawole Olaniyi A, Makunga Nokwanda P, Opara Umezuruike L. Effect of drying on the bioactive compounds, antioxidant, antibacterial and antityrosinase activities of pomegranate peel. BMC Complementary and Alternative Medicine. 2016;16(1):143.
62. Santos PHS, Silva MA. Retention of Vitamin C in Drying Processes of Fruits and Vegetables-A Review. Drying Technology. 2008;26(12):1421-1437.
63. Arballo JR, Campañone LA, Mascheroni RH. Modeling of Microwave Drying of Fruits. Part II: Effect of Osmotic Pretreatment on the Microwave Dehydration Process. Drying Technology. 2012;30(4):404-415.
64. Shahdadi F, Mirzaei HO, Daraei Garmakhany A, Mirzaei H, Ghafori Khosroshahi A. Effect of drying process on antioxidant properties of date palm fruits. Minerva Biotecnologica. 2013;25(4):235-243.
65. Prajapati VK, Prabhat Nema K, Rathore SS. Effect of pretreatment and drying methods on quality of value-added dried aonla (*Emblica officinalis* Gaertn) shreds. 2011;48(1):45-52.
66. Paul Indira Dey, Das Madhusweta. Effect of freeze, microwave-convective hot air, vacuum and dehumidified air drying on total phenolics content, anthocyanin content and antioxidant activity of jamun (*Syzygium cumini* L.) pulp, 2018.
67. Anjum MA, Haram A, Ahmad R, Bashir MA. Physico-chemical attributes of fresh and dried Indian jujube (*Zizyphus mauritiana*) fruits. Pakistan Journal of Agricultural Sciences, 2020, 57(1).
68. Pareek Sunil, Kaushik RA. Effect of drying methods on quality of Indian gooseberry (*Emblica officinalis* Gaertn.) powder during storage, 2012.
69. Elmas Feyza, Varhan Emine, Koç Mehmet. Drying characteristics of jujube (*Zizyphus jujuba*) slices in a hot air dryer and physicochemical properties of jujube powder. Journal of Food Measurement and Characterization, 2018.
70. Briki Samia, Zitouni Bariza, Bechaa Besma, Amiali Malek. Comparison of convective and infrared heating as means of drying pomegranate arils (*Punica granatum* L.). Heat and Mass Transfer, 2019.
71. Muzaffar Khalid, Kumar Pradyuman. Spray Drying of Tamarind Pulp: Effect of Process Parameters Using Protein as Carrier Agent. Journal of Food Processing and Preservation, 2016.
72. Bhusari Shridhar N, Pradyuman Kumar. Antioxidant activities of spray dried tamarind pulp powder as affected by carrier type and their addition rate. In International Conference on Food, Biological and Medical Sciences (FBMS-2014), Bangkok (Thailand), 2014.
73. Singh Chandra Shekhar, Paswan Vinod Kumar, Chandra Rai Dinesh. Process optimization of spray dried Jamun (*Syzygium cumini* L.) pulp powder. LWT, 2019.
74. Raman Rakesh Kumar, Swaminathan Santhalakshmy, Sowriappan John, Don Bosco, Sangita Ganguly. Phytochemical properties of spray dried jamun juice powder as affected by encapsulating agents. Journal of Pharmacognosy and Phytochemistry. 2020;9(3):599-602.
75. Kapoor Swati, Ranote Pushpinder Singh. Antioxidant components and physico-chemical characteristics ofjamunpowder supplemented pear juice. Journal of Food Science and Technology. 2016;53(5):2307-2316.
76. Hazra Sudipto Kumar, Molla Salauddin, Tanmay Sarkar, Anirban Roy, Runu Chakraborty. Effect of freeze drying on anti-oxidant properties of bael fruit (*Agle marmelos*). In Biotechnology and biological sciences, Proceedings of the 3rd International Conference of Biotechnology and Biological Sciences, pp. 426-430. CRC Press: Kolkata, India, 2019.
77. Hazra Sudipta Kumar, Sarkar Tanmay, Salauddin Molla, Sheikh Hassan I, Pati Siddhartha, Chakraborty Runu *et al*. Characterization of phytochemicals, minerals and in vitro medicinal activities of bael (*Aegle marmelos* L.) pulp and differently dried edible leathers, 2020.
78. Faroda AS, Joshi NL, Singh R, Saxena A. Resource management for sustainable crop production in arid zone–A review. Indian Journal of Agronomy. 2007;52(3):181-193.
79. Singh AK, Sanjay Singh, Saroj PL, Mishra DS, Vikas Yadav, Raj Kumar *et al*. Cultivation of underutilized fruit crops in hot semi-arid regions: developments and challenges - a review. Current Horticulture. 2020;8(1):12-23.
80. Nandal U, Bhardwaj RL. The role of underutilized fruits in nutritional and economic security of tribals: A review. Critical reviews in food science and nutrition. 2014;54(7):880-890.
81. Perez-Aguilar LY, Plata-Rocha W, Monjardin-Armenta SA, Franco-Ochoa C, Zambrano-Medina YG. The Identification and Classification of Arid Zones through Multicriteria Evaluation and Geographic Information Systems-Case Study: Arid Regions of Northwest Mexico. ISPRS International Journal of Geo-Information. 2021;10(11):720.
82. Abatzoglou JT, Dobrowski SZ, Parks SA, Hegewisch KC. Terra Climate, a High-Resolution Global Dataset of Monthly Climate and Climatic Water Balance from 1958–2015. Sci. Data 2018, 5, 1–12. [CrossRef]
83. El-Sharnouby GA, Al-wesali MS, Al-Shathri AA. May. Effect of some drying methods on quality of palm date

fruits powder. In The Fourth Symposium on Date Palm in Saudi Arabia. King Faisal University, 2007, 5-8.
84. Sivakumar R, Saravanan R, Perumal AE, Iniyan S. Fluidized bed drying of some agro products–A review. Renewable and Sustainable Energy Reviews. 2016;61:280-301.
85. Kumar Y, Belorkar SA. Fluidized Bed Drying of Fruits and Vegetables: An Overview. Int. J. Eng. Stud. techn. Approach. 2015;1(9):1-8.
86. Lee HX, Ahmad F, Saad B, Ismail MN. Evaluation of extraction methods for the identification of proteins from date palm (*Phoenix dactylifera* L.) seed and flesh. Preparative Biochemistry and Biotechnology. 2017;47(10):998-1007.
87. Cherif S, Le Bourvellec C, Bureau S, Benabda J. Effect of storage conditions on 'Deglet Nour'date palm fruit organoleptic and nutritional quality. LWT. 2021;137:110343.
88. Bentrad Najla, Asma Hamida-Ferhat. Date palm fruit (*Phoenix dactylifera*): Nutritional values and potential benefits on health. In The Mediterranean Diet, 2020, 239-255. Academic Press.
89. Elmas Feyza, Emine Varhan, Mehmet Koç. Drying characteristics of jujube (*Zizyphus jujuba*) slices in a hot air dryer and physicochemical properties of jujube powder. Journal of Food Measurement and Characterization. 2019;13(1):70-86.
90. Salehi F. Recent Applications of Heat Pump Dryer for Drying of Fruit Crops: A Review. International Journal of Fruit Science. 2021;21(1):546-555.
91. Wojdyło A, Lech K, Nowicka P, Hernandez F, Figiel A, Carbonell-Barrachina AA *et al*. Influence of different drying techniques on phenolic compounds, antioxidant capacity and colour of *Ziziphus jujube* Mill. Fruits. Molecules. 2019 Jan;24(13):2361.
92. Das Priyanka, Archana Singha Dutta. A comparative study on drying of ber. Journal of Agricultural Engineering. 2013;50(1):34-38.
93. Gao QH, Wu CS, Wang M. The jujube (*Ziziphus jujuba* Mill.) fruit: a review of current knowledge of fruit composition and health benefits. Journal of agricultural and food chemistry. 2013;61(14):3351-3363.
94. Hernández F, Noguera-Artiaga L, Burló F, Wojdyło A, Carbonell-Barrachina ÁA, Legua P *et al*. Physico-chemical, nutritional, and volatile composition and sensory profile of Spanish jujube (*Ziziphus jujuba* Mill.) fruits. Journal of the Science of Food and Agriculture. 2016;96(8):2682- 2691.
95. Al-Farsi Mohamed, Cesarettin Alasalvar, Anne Morris, Mark Baron, Fereidoon Shahidi. Compositional and sensory characteristics of three native sun-dried date (*Phoenix dactylifera* L.) varieties grown in Oman. Journal of agricultural and food chemistry. 2005;53(19):7586-7591.
96. Juhaimi FA, Ghafoor K, Özcan MM. Physical and chemical properties, antioxidant activity, total phenol and mineral profile of seeds of seven different date fruit (*Phoenix dactylifera* L.) varieties. International journal of food sciences and nutrition. 2012;63(1):84-89.
97. Shawky S, Rabie SMH, Assous MTM, Zeinab M. Impact of Pretreatments and Drying Temperatures on Quality of Siwi and Sakkoti Dates. Pakistan journal of biological sciences: PJBS. 2020;23(5):658-666.
98. Hussain Iftikhar M, Muhammad Farooq, Qamar Abbas Syed. Nutritional and biological characteristics of the date palm fruit (*Phoenix dactylifera* L.)–A review. Food Bioscience. 2020;34:100509.
99. Yılmaz FM, Yüksekkaya S, Vardin H, Karaaslan M. The effects of drying conditions on moisture transfer and quality of pomegranate fruit leather (pestil). Journal of the Saudi Society of Agricultural Sciences. 2017;16(1):33-40.
100. Kaveh M, Golpour I, Gonçalves JC, Ghafouri S, Guiné R. Determination of drying kinetics, specific energy consumption, shrinkage, and colour properties of pomegranate arils submitted to microwave and convective drying. Open Agriculture. 2021;6(1):230-242.
101. Chandra R, Jadhav VT, Sharma J. Global scenario of pomegranate (*Punica granatum* L.) culture with special reference to India. Fruit Veg Cereal Sci. 2010;4(2):17-8.
102. Cherif S, Le Bourvellec C, Bureau S, Benabda J. Effect of storage conditions on 'Deglet Nour'date palm fruit organoleptic and nutritional quality. LWT. 2021;137:110343.
103. Gökçen İZLİ. Total phenolics, antioxidant capacity, colour and drying characteristics of date fruit dried with different methods. Ciência e Tecnologia de Alimentos. 2017;37(1):139-147.
104. Bentrad Najla, Asma Hamida-Ferhat. Date palm fruit (Phoenix dactylifera): Nutritional values and potential benefits on health. In The Mediterranean Diet, 2020, 239-255. Academic Press.
105. Mechlouch Ridha Fethi, Ahlem Ayadi, Gouta Thabet EOEH Hannachi, Walid Elfalleh. Changes in the Physico-Chemical Properties of Palm Date using different drying methods. University Bulletin. 2015;17(1):59-78.
106. Hota M, Dahiya DS, Kumar S. Effect of Various Drying Methods on Drying Time and Quality of Pomegranate (*Punica granatum* L.) Arils. Int. J Curr. Microbiol. App. Sci. 2017;6(4):1711- 1717.
107. Horuz E, Maskan M. Hot air and microwave drying of pomegranate (*Punica granatum* L.) arils. Journal of Food Science and Technology. 2015;52(1):285-293.
108. El-Sharnouby Gamal A, Mohamed Al-wesali S, Abdulaziz Al-Shathri A. Effect of some drying methods on quality of palm date fruits powder. In The Fourth Symposium on Date Palm in Saudi Arabia. King Faisal University, May 2007, 5-8.
109. Okello J, Okullo JB, Eilu G, Nyeko P, Obua J. Mineral composition of *Tamarindus indica* LINN (Tamarind) pulp and seeds from different agro-ecological zones of Uganda. Food science & nutrition. 2017;5(5):959-966.
110. Singh AK, Sanjay Singh, Saroj PL, Mishra DS, Vikas Yadav, Raj Kumar *et al*. Cultivation of underutilized fruit crops in hot semi-arid regions: developments and challenges-a review. Current Horticulture. 2020;8(1):12-23.
111. Ahmed, Naseer, Jagmohan Singh, Harmeet Chauhan, Prerna Gupta Anisa Anjum, and Harleen Kour. "Different drying methods: their applications and recent advances." *International Journal of food nutrition and safety* 4, no. 1 (2013): 34-42.
112. Nemzer, Boris, Luis Vargas, Xiaoyan Xia, Marsha Sintara, and Hao Feng. "Phytochemical and physical properties of blueberries, tart cherries, strawberries, and

cranberries as affected by different drying methods. Food Chemistry. 2018;262:242-250.
113. Wojdyło Aneta, Ángel A, Carbonell-Barrachina, Pilar Legua, Francisca Hernández. Phenolic composition, ascorbic acid content, and antioxidant capacity of Spanish jujube (*Ziziphus jujube* Mill.) fruits. Food chemistry. 2016;201:307-314.
114. Maraghni Mouna, Mohamed Neffati. Effect of salinity on seed germination of wild jujube *Ziziphus lotus* (L.) Lam. Singh, Sanjay, D. S. Mishra, and A. K. Singh. "Tamarind (*Tamarindus indica* L.). Tropical Fruit Crops Theory to Practical, 2021, 610-631.
115. Singh Om, Sanjay Pathak, Richa Singh. Studies on suitable blending ratio for the preparation Of aonla based quality beverages. Annals of Horticulture. 2013;6(2):198-204.
116. Krishna Hare, Avinash Parashar. Phytochemical Constituents and Antioxidant Activities of Some I ndian Jujube (*Z iziphus mauritiana* Lamk.) Cultivars. Journal of Food Biochemistry. 2013;37(5):571-577.
117. Zhang Min, Bhesh Bhandari, Zhongxiang Fang. Handbook of drying of vegetables and vegetable products. CRC Press, 2017.
118. Senapati, AK, Varshney AK, Sharma VK, Patel S. Fluidized bed drying of food: A review.
119. Sagar VR, Suresh Kumar P. Recent advances in drying and dehydration of fruits and vegetables: a review. Journal of food science and technology. 2010;47(1):15-26.
120. Chandra Suresh, Durvesh Kumari. Recent development in osmotic dehydration of fruit and vegetables: a review. Critical reviews in food science and nutrition. 2015;55(4):552-561.
121. Kumar Yashwant, Seema Belorkar A. Fluidized bed drying of fruits and vegetables: An overview. International Journal of Engineering Studies and Technical Approach. 2015;1(9):1-8.
122. Hasan Mahmood Ul, Aman Ullah Malik, Sajid Ali, Amna Imtiaz, Anjum Munir, Waseem Amjad *et al*. Modern drying techniques in fruits and vegetables to overcome postharvest losses: A review. Journal of Food Processing and Preservation. 2019;43(12):e14280.
123. Khan Rao Sanaullah, Waqas Asghar, Nauman Khalid, Wahab Nazir, Muhammad Farooq, Iftikhar Ahmed *et al*. Phalsa (*Grewia asiatica* L) fruit berry a promising functional food ingredient: A comprehensive review. Journal of Berry Research. 2019;9(2):179-193.
124. Nayik GA, Gull A (Eds.). Antioxidants in Fruits: Properties and Health Benefits, 2020. doi:10.1007/978-981-15-7285-2
125. Kishore K, Mahanti KK, Samant D. Phenological growth stages of bael (*Aegle marmelos*) according to the extended Biologische Bundesantalt, Bundessortenamt und Chemische Industrie scale." Annals of Applied Biology. 017;170(3):425-433.
126. Singh KS. Multiplication of Phalsa (*Grewia asetica* L.) Cv. Dwarf type through hardwood stem cutting under Srinagar Garhwal Himalayas." International Journal of Current Microbiology and Applied Sciences. 2017;6(2):1173-1178.
127. Khan Rao Sanaullah, Waqas Asghar, Nauman Khalid, Wahab Nazir, Muhammad Farooq, Iftikhar Ahmed *et al*. Phalsa (*Grewia asiatica* L.) fruit berry a promising functional food ingredient: A comprehensive review. Journal of Berry Research. 2019;9(2):179-193.
128. Pal Dilipkumar, Souvik Mukherjee. Tamarind (*Tamarindus indica*) seeds in health and nutrition. In Nuts and Seeds in Health and Disease Prevention, pp. 171-182. Academic Press, 2020.
129. Mansingh B, Brailson JS, Binoj N, Prem Sai, Shukur Abu Hassan, Suchart Siengchin *et al*. Sustainable development in utilization of *Tamarindus indica* L. and its by-products in industries: A review. Current Research in Green and Sustainable Chemistry. 2021;4:100207.
130. Yadav Ajay, Nishant Kumar, Ashutosh Upadhyay, Pratibha, Rahul Kumar Anurag *et al*. Edible packaging from fruit processing waste: a comprehensive review. Food Reviews International, 2021, 1-32.
131. Habib Hosam M, Wissam Ibrahim H. Nutritional quality evaluation of eighteen date pit varieties. International Journal of Food Sciences and Nutrition. 2009;60:99-111.
132. Nayik Gulzar Ahmad, Amir Gull eds. Antioxidants in Fruits: Properties and Health Benefits. Berlin/Heidelberg, Germany: Springer, 2020.
133. Devi Barsha, Tridip Boruah. Tamarind (*Tamarindus indica*). In Antioxidants in Fruits: Properties and Health Benefits. Springer, Singapore, 2020, 317-332.
134. Ahmed Naseer, Jagmohan Singh, Harmeet Chauhan, Prerna Gupta Anisa Anjum, Harleen Kour *et al*. Different drying methods: their applications and recent advances." International Journal of food nutrition and safety. 20134(1):34-42.
135. Wojdyło Aneta, Ángel A, Carbonell-Barrachina, Pilar Legua, Francisca Hernández. Phenolic composition, ascorbic acid content, and antioxidant capacity of Spanish jujube (*Ziziphus jujube* Mill.) fruits. Food chemistry. 2016;201:307-314.
136. Joshi VK, Rakesh Sharma, Aman Girdher, Ghan Shyam Abrol. Effect of dilution and maturation on physico-chemical and sensory quality of jamun (Black plum) wine, 2012.
137. Singh Krishan Kumar, Shiv Pratap Singh. Cultivation and utilization in Phalsa (*Grewia asiatica* L.) under Garhwal Himalayas region. Journal of Medicinal Plants Studies. 2018;6(1):254-256.