CHAPTER 1

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Tamarillo also known by the name of tree tmato (*Solanum betaceum*) belongs to the same family of tomato. Tamarillo is a native fruit from Peru, Bolivia, and Brazil [1]. In India, tamarillo grows in the north eastern region and its availability is more in winter season in the states of Nagaland, Sikkim and Meghalaya. Tamarillo is a seasonal and nutritionally rich fruit [3]. Tamarillo is very different from tomatoes. Ripe tomatoes are red in colour because of lycopene content whereas tamarillos are available in red, yellow or purple colours due to the presence of anthocyanins and carotenoids. Tamarillo can be fragmented into three parts: peel, pulp and seed mucilage and all the parts of the fruits are edible.

Tamarillo contains high levels of vitamin C compared to tomatoes; red tamarillo is the only fruit where pigments like anthocyanins (water soluble) and carotenoids (water insoluble) are found in abundance together [25]. All the components present in tamarillo have health benefits and show anti-obesity and anti-inflammatory properties, prevent retinal degradation, and enhance the immune system, etc. [29]. Yellow variety of tamarillo is loaded with high amount of carotenoids, vitamins like A, B6 and E, and minerals such as calcium, iron, and phosphorus. The major carotenoids that are present in tamarillo are β-cryptoxanthin (45.3%) followed by β-carotene (26.1%), zeaxanthin (5.1%) and antheraxanthin (4.0%), besides neoxanthin, neochrome, phytoene, and β-cryptoxanthin, zeinoxanthin, and 5,6-epoxy-β-carotene in minor quantities [5]. The phenolic composition in tamarillo consists of hydroxycinnamoyl derivatives and is reported to vary between 60.25 and 110.23 mg/100 g dry basis (db) in yellow and 132.57 and 421.55 mg/100 g (db) in purple tamarillo cultivars of New Zealand [10]. The major phenolic acid is caffeoylquinic acid followed by rosmarinic acid [10, 25]. Delphinidin, cyanidin and pelargonidin glycosides are the major anthocyanin compounds [28] present in the purple and red varieties. Yellow variety has no anthocyanins. The concentration of anthocyanins in purple cultivars was reported to range between 102 and 169 mg/100 g db [10].

The fruit grown in Nagaland has been registered as a GI (Geographical Indication) crop of Nagaland. In Nagaland, during the winter season, tamarillo is utilized as a substitute for tomato because its sensorial parameters are said to be better than tomato. Tamarillo is eaten in many ways like raw fruit in salad, as a dessert fruit in the north eastern region. The peel is not much liked by the consumer because of its astringent taste and thick texture. Processed products are not available in the Indian market. Therefore, this fruit has an immense scope for value addition and commercialisation in the state.

Ultrasonication is an effective, efficient and reproducible technique for the recovery of the bioactives from pulp [12]. Ultrasonication enhances the quality and yield of the extract and reduces the operating time [31]. Recently, supercritical fluid extraction (SCFE) has been widely applied in the extraction or separation of bioactive components with CO_2 at different pressure and temperature in acidified ethanol used as modifier [18]. Response surface methodology (RSM) is a method for improving, developing, and optimising processes, and used to assess the effect of the independent variables and their interactions on the dependent variables [11, 34]. Different studies have been reported for the optimization of extraction of bioactive compounds using RSM and developing the best conditions for the extraction procedure. Sharayei et al. [30] optimized the extraction parameters by RSM and reported that ultrasonic exposure time and amplitude of ultrasound have high impact on extraction of phytochemicals from the sample matrix. There is scope for extraction of tamarillos of north east region using ultrasonication and supercritical fluid extraction for profiling of the bioactives present.

Carotenoids are located inside the chromoplast of the fruits and vegetables embedded in the cellular structure [17]. Thermal treatment of fruits and vegetables pulp results in more absorption of carotenoids from the small intestine when compared to non-treated fruits and vegetables [14, 26]. Thermal treatment helps in transformation in the trans to *cis* isomerization in canned tomato [23]. High pressure homogenization is a useful technique to disrupt cellular matrix for easy extraction of carotenoids. The homogenised carotenoids with thermal treatment have positive effects on the bioaccessibility and bioavailability [7, 13]. Carotenoids absorption in body depends upon numerous factors like linkages at molecular level, species of carotenoids, amount of carotenoid, genetics, effectors, nutrient status, host related factors, interactions and matrix among these variables and all these factors play important role in bioaccessibility

and bioavailability [33]. Processing tamarillo into puree form and its canning will not only upsurge the shelf life of the product and availability of this fruit round the year but also increase the bioavailability of the carotenoids present.

Drying of perishable food into stabilized product improves the shelf life of the product and gives stability against chemical, deteriorative microbial, and biochemical reactions including packaging and handling [22]. Hot air drying is an easy, economical method for the preservation of foods but it affects the quality parameters of food products [8]. Yang et al. [19] observed that phenolics and anthocyanins are degraded during the drying but carotenoids remain stable as they are heat stable [6, 27]. On the other hand, freeze drying is a gentle dehydration method for the production of high quality product by minimizing the degradation of bioactive compounds [21, 24]. Foam mat drying technique is another drying technique wherein the exposure of larger surface area to heat decreases the drying time and retains the nutrients [2]. The selection and addition of foaming agents and stabilizers in foam-mat drying plays an vital role in the formation and stability of foams. Additives like albumen, maltodextrin, and skim milk powder give stability to the foams [32]. The retention of colour, flavour, nutritional and organoleptic characteristics and acceptable shelf life in the processed product are the foremost requirements of the process technology [20]. Drying of tamarillo pulp into powder offers another way for its valorisation.

Carotenoids are lipophilic compounds and known for their health beneficial properties. Health benefits of carotenoids are improved by preventing its degradation and improving its water solubility, and for that incorporation of carotenoids into the oil phase and preparation of oil-in-water nanoemulsion will be a feasible method for its delivery [4, 15]. Nanoemulsions are known for their improved physical and high optical stability [16]. Seed oils are utilized globally as good source of unsaturated fatty acids and essential amino acids. Seed oils are rich source of phytochemicals that exhibit antioxidant property and has proven health benefits. Tamarillo seeds are reported to be high in lipid content having palmitoleic (0.23%), linolenic (1.70 %), stearic (2.12%) acids, palmitic (9.68%), oleic (16.18%) and linoleic acid (70%) [9]. Tamarillo seed oil offers an opportunity for use in nanoemulsion development. Development of nanoemulsions of carotenoids of tamarillo using its seed oil will be an interesting area to explore.

Objectives

In the light of the limited literature reports on the scope of work on tamarillo as identified above, following objectives of the study have been proposed:

- To analyse the biochemical properties, nutrient composition, and antioxidant activities of the red, yellow, and purple varieties of tamarillo.
- To optimize the extraction of polyphenols from tamarillo pulp using ultrasonication and supercritical fluid extraction techniques and identify the polyphenols in optimized extracts.
- To standardize the bottling of tamarillo puree and study the *in vitro* bioaccessibility of carotenoids.
- To develop tamarillo powder using different drying methods and study drying behaviour and powder properties.
- To study the physical and chemical properties of tamarillo seed oil nanoemulsions incorporated with extracted carotenoids of the fruit.

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