Application of Spray Drying process to convert Beneficial Compounds extracted from Plants into free-flowing powder

Ankith Sanjay Thampi, Saurabh Ravi kumar, Gowtham Sanjai S and Parvati Ramaswamy

Department of Mechanical and Automobile Engineering, CHRIST (Deemed to be University), Bangalore, India.

* Corresponding author: gowthamsanjai.s@christuniversity.in

Abstract. The use of herbal tablets has been rapidly growing and significant research work is being carried out worldwide with the goal to reap the benefits of the many useful plants that are available with medicinal values. Many of these plants go largely underutilized either due to lack of information on not only just the medicinal properties but simple and effective extraction methodologies as well, without sacrificing the properties of the extracts. Once extracted, the concentrates also must be converted into a suitable form that can be loaded in a capsule etc., ready to be consumed. While there many process methodologies being used worldwide to extract the useful resources from the plant, focus also must be on the process methodology that is being practiced to convert the extract (liquid or semi solid) into a solid free flowing powder form. Thus, in an herbal tablet, there many factors concerned with the manufacturing. They are (i) Identifying the most suitable plant for a particular immunity boosting purpose (ii) extraction of the useful contents, mostly in a liquid or slurry form (iii) transform the extract into a user-friendly product such as powder and finally (iv) encapsulation of the powder for ease of human consumption. This paper brings in a review of the several useful plants available around us across the world. In addition, the paper also highlights the suitable experimental results of the usefulness of spray-drying technology, which is a highly versatile process methodology to transform the extracts into free-flowing powder.

1. Introduction
Chronic diseases have affected humans for many years but the solutions to these problems have always been present in nature. While plants may not offer an immediate solution to the diseases, but they do offer immunity to many common ailments so that these diseases do not affect the body at all. Many plants have shown anti-diabetic, anti-allodynic, anti-proliferative, anti-microbial and various other immunity building properties. Since many years neem, ginger, tulsi and various other plants have been used commonly for treatment of stomach upset, respiratory issues, liver disorders and various other ailments. In recent years, various studies have proven that extracts from the plants and their consumption have shown to have higher anti-oxidative properties as compared to the plant by itself [1]. Furthermore, some medicinal plants may not be practically consumable due to their strong or pungent taste. In order to completely absorb the valuable contents of the plant extract (liquid or slurry form); it is beneficial to convert the extracts into a powder form. This paper presents the usefulness of the spray drying methodology to achieve the conversion of plants extracts into a free flowing and easily absorbable powder.

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Spray drying involves the atomization of a fluid feed into extremely small driblets inside a chamber, circulating hot drying gas and prompting the drying of the driblets into agglomerated fine particles. The particles collect in the scrubber are recovered the drying gas, utilizing a tornado or potentially a filter, as the last spray dried powder. The various parameters taken into consideration while spray drying an extract are: (a) inlet temperature, (b) atomization pressure, (c) feed rate and (d) aspiration rate etc. Some of the challenges faced by researchers while working on the plant extract are dealing with are (a) the adhesive and cohesive forces present between the extract and the spray dryer wall, (b) particulate size of spray dried particles (c) control of extract properties and (d) the process yield. The resulting spray dried powder (SDP) characteristics vary depending upon these parameters. To reduce the challenges faced during the spray drying process and to increase the SDP yield, carrier materials are introduced into the feed/slurry. One such highly efficient carrier is Maltodextrin (food additive). The SDP obtained during the various processing, also show the presence of phenolic compounds which is a reducing agent used to prevent oxidative stress in a human body [2, 3].

Spray dried powders are characterized by the compactness of the spray dried powder (SDP) and the random dense packing of SDP is defined by the bulk and tap density respectively. To collect the information on the size, shape or the surface form of the SDP, Particle morphology is studied by the use of Scanning electron microscope (SEM), X-ray diffraction (XRD) and thermal analysis. This review paper showcases the spray drying process performed on the extracts of few useful plants to obtain the SDP (in order to contain the valuable properties into a carrier fit for consumption). Furthermore, the encapsulation of the SDP in a type that is ready for consumption, without sacrificing the nutrients is also brought out in the paper. In addition to the review, preliminary results obtained from an experiment involving spray drying of a suspension of plant extract (containing iron as a nutritional supplement) is also included for general information purposes.

2. Purpose and principle of Spray Drying

Spray Dryer may be a process of conversion of liquid or slurry (solids suspended in a liquid) form into solid part as a powders. This is done by removing moisture content from the liquid solution. Solid powders can be synthesized even by drying the liquid / slurry in a hot air oven: but spray drying is most preferred due to the several advantages it offers over hot air oven drying. Spray drying is different from oven drying in the sense that the resulting SDP is free flowing (if required), not in the form of hard lumps, laden with pre-requisite moisture content, retained nutrition etc. That is the powder morphology; composition, uniformity, size and shape etc. can be closely controlled by spray drying which cannot be done by oven drying. In the spray drying process of medicinal herbs, the liquid herb extract is atomized through a special pressure nozzle with a high-pressure pump. Hot air enters the dryer by an air distributor. The material and also the air is mixed within the dryer, rapidly carries the transformation of warmth and mass. Powders are produced in a very short time (may take hours depending upon slurry/liquid properties, final powder quantity desired and the settings). Products with larger particles are discharged from the underside of the dryer, smaller particles enter the cyclone with hot air. The exhaust gas is discharged into the air after dust removal in a scrubber. It has high operational flexibility on non-adhesive or low adhesive liquid materials with less power consumption and low cost.

A photograph of the spray dryer used for spraying a medicinal plant extract containing iron supplement, Extract and SDP are shown in Figure 1. The brown coloration of the SDP, sticking to the walls of the drying chamber is typical of the iron supplements (Fig 1a), associated with the characteristics of the smell it evolved during the performance of the spray drying experiment. The extract and SDP are shown in Fig 1 (b) and (c) respectively.
Figure 1. (a) Spray dryer used for spraying a medicinal plant extract containing iron supplement and (b) Slurry of Iron based plant extract, ready for spray drying (shown by black arrow Figure in 1a). Brown SDP is also seen in the drying chamber (red arrow) (c) SDP after removal from the chamber

3. Review of literature on useful plants, extraction, spray drying and findings

Table 1 gives the botanical names of a few typical herbs, common names, origin and uses of few medicinal plants.

| S. No. | Herb (Botanical name) | Common Name | Nativity | Medicinal Uses |
|-------|----------------------|-------------|----------|----------------|
| 1.    | Ocimum sanctum       | Tulsi       | India    | Throat Infections, Respiratory problems |
| 2.    | Zingiber officinale  | Ginger      | India    | Reduces Blood pressure |
| 3.    | R. Purshiana         | Bearberry   | Canada   | Occasional constipation |
| 4.    | P. Boldus            | Boldo       | South America | Liver stimulant (Cholagogue) |
| 5.    | C. asiatica          | Indian pennywort | India | Alleviate vein related disorders (Venotonic Anti cellulite) |
| 6.    | D. officinalis       | Garden Heliotrope | Peru | Mild sedative and sleep promoting agent |
| 7.    | H. virginiana        | Witch- Hazel | North America | Venotonic for the treatment varicose veins |
| 8.    | I. perforatum        | St John’s wort | Europe | Treatment of mild and moderate depressive episodes |
| 9.    | B. forficata         | Brazilian Orchid Tree | Brazil, Peru | Used mainly for their antidiabetic properties |
| 10.   | Phyllanthus Niruri   | Gale of the wind Roselle | India | Urinary Tract stones |
| 11.   | Hibiscus sabdariffa  | Roselle     | India    | Promote weight loss , reduce blood pressure |
| 12.   | Olea Europaea        | Olive       | Europe, Africa, West Asia | Reduces cardio-vascular risk, boosts immunity |
| 13.   | Tinospora cordifolia | Moonseed    | India    | Controls diabetes,, high cholesterol |
| 14.   | Helianthus           | Sunflower   | North America | Boosts heart Health, rich in antioxidant properties |
| 15.   | Capiicum annuum      | Chilli      | Worldwide | Excellent source of vitamins. |
Loreana Gallo et al. have reported the results of a study carried out on the following medicinal herbs and leaves: (a) Rhamnus purshiana D.C., (b) Peumus boldus Mol., (c) Centella asiatica leaves, (d) Valeriana officinalis leaves, (e) Hypericum perforatum leaves, (f) Hamamelis virginiana leaves, and (g) Cynara scolymus leaves. The common names are also included in Table 1. Although many herbs and extracts were used in the study by these authors, only one set of spray-drying parameters were generated and optimised in the paper, with focus on flowability, stability and compact ability of the spray dried powder. The study involved spray drying the aqueous extracts of the plants, drying performance and product quality. The Fluid Plant Medicinal Extracts (FPMEs) were prepared for all of the selected herbs (details not provided). The solid residue (SR) content of the FPMEs was determined by a standard test method by employing a hot air oven. Sprays drying of the FPMEs were carried out with aqueous solutions dispersed for 30 min before atomization and also a magnetic stirrer was used at 1000 rpm to keep the solution homogenized. Spray drying parameters used were (a) orifice diameter - 0.5mm, (b) inlet temperature - 130 °C, (c) feed flow rate: 3ml/min, (d) air volumetric flow rate - 400l/h, (e) drying air volumetric flow rate: 35 - 35 m³/h. SDP comprises (a) mean particle diameter between 7.79 ± 1.48 and 9.81 ± 1.60 μm, (b) mean moisture content in the range of 2.00 ± 0.17 to 2.69 ± 0.03 %, (c) moderate hygroscopicity between 9.11± 0.03 and 11.09 ± 0.08g per 100g of dry solids were obtained. The SDP showed that, the higher the repose angle the higher was the cohesivity, the bulk density was lowered correspondingly. The high ease in manufacturing, applicability and utility of the SDP in the form of tablets (consistent dosage), was also highlighted [4].

Angelica G. Couto et al. studied the extraction and spray drying characteristics of Phyllanthus niruri parts. Figure 2 shows a photograph of the Niruri plant. This plant possesses anti-inflammatory, anti-allodynic effects (useful to treat migraine, chronic pain management) and quantitative analysis of gallic acid (useful component) in the spray dried powders. The aqueous extraction was carried out by using the leaves, stem and roots and the extract was spray dried by using miniature spray dryer.

The spray drying conditions were as the following. Nozzle aperture (0.7 mm), spraying pressure (200 kPa), flow of the solution (at 3ml/min). Pharmacological studies included (i) Von Frey Test on Animals (male swiss mice) (ii). Drugs and extraction administration (iii) Myleperoxidase activity (iv) Carrageenan-induced mechanical allodynia, and (v) Data analysis such as powder morphology by using Scanning Electron Microscopy (SEM). The analysis was based on studying the influence (particle diameter) of concentration of the gallic acid in the different SDP mixtures. The highest yield of gallic acid was from the SDP of leaves compared to the mixture of the stems and leaves. The SDP of leaves and stem decreased the allodynia (pain) by 48% in the Von Frey test in 4 hours and was also effective in inhibiting the paw oedema (swelling) formation upto 35%. The results obtained from the SDP of leaves and stems synergised and could be used as the starting materials for analgesic phytopharmaceutical purpose. [5]

Salvador Gonzalez-Palomares et al. studied the characteristics of the Roselle Calyx which is the part of the plant Hibiscus sabdariffa and is utilised in preservation of jellies, jams and fruit preserves for its high content of pectin and absorbic acid. The Roselle extraction were carried out by the process of maceration with 7L of 30% ethanol and then the extracts were spray dried at different inlet temperature ranging from 150˚C to 210˚C and the outlet temperature was maintained at 80 °C with the atomizer rate of 26000 rpm. The collected sample of powder was then checked for the moisture content by using a vacuum stove and the pH were recorded. The process of powder reconstitution was carried out using 300mL of distilled water. The volatile analysis of Roselle extracts was carried out using Solid phase micro
extraction (SPME) using a PTFE-faced silicone septum. The sensorial and the statistical analysis was done for each of the collected powder samples. The Roselle powder showed a tendency to stick to stainless steel surfaces of the drying chamber at high inlet temperature because of low feed rate. It was also observed that the pH of the powder does not change with varying temperature treatment. They were around 20 volatile compounds found in the SPME and GC-MS analysis of Roselle extract, which were mainly aldehydes and phenolic compounds (useful for preservation). The data obtained in terms of (i) weight (ii) humidity, and (iii) pH values of samples at different temperature showed that the temperature of 190°C (inlet temperature) gave the highest concentration of volatile compounds. [6] Konstantinos Kiritsakis et. al. have studied the valorization (convert into useful products) of olive leaves. The use of the olive leaves has extensively been used in various medicinal, cosmetics, pharmaceutical industries which makes it very useful in these applications. The extract was obtained using ultrasound-assisted extractor in the pulse mode and the resulting extracts were centrifuged for 3 minutes at 800 rpm. The dehydrated extract of the olive leaf has a reduction in total phenolic content and antioxidant capacity of around 10%. Spray drying is used as it has several advantages such as flexibility and applicability to heat sensitive-materials.

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The product recovery was calculated using the formula: total mass collected divided by the total mass to be spray dried. The product recovery varied between 72.81% and 76.49% for different olive cultivations. The characterization of Olive leaf extract was conducted and different properties such as total Phenolic Content, thermal stability and Rheological Characterization were studied. (ii) Differential Scanning Calorimetry (DSC) was used to perform some of the above studies. The SDP obtained were analysed for (a) moisture (b) Bulk density, (c) Hygroscopicity (d) Total Phenolic Content and (e) Particle Morphology. Statistical analysis and optimization was carried out to identify the significance effect and interaction between the highest level and the lowest level of a particular factor. The solid concentrations >17% in the extract led to clogging problems in the atomizer and the tubes. In certain cultivar instead of powder toffee like small solids were deposited in the chamber walls. Product recovery and wall deposits also depended on the drying air. Moisture content was an important parameter as it decided the shelf life of the product; the moisture content also decreases with increase in inlet air temperature. The optimization of the spray drying process was conducted for selected range of inlet air temperature which varied between 4.5% up to ~10.4% depending upon the leaf extract. The bulk density varied (0.161 to 0.333 g/ml) according to different cultivar properties. The spray dried olive powder has use as food additives and stickiness also is affected by cultivar characteristics. Spray drying of olive leaves extracts improved stability and ease of storage. [7] M. Sarala et. al have studied the antioxidant properties of the Guduchi plant (Tinospora cordifolia) which is widely used in ayurvedic medicine. It is used as a general tonic, anti-periodic, anti-arthritic and as other powerful immune modulators. The authors describe the spray drying process associated with Guduchi leaves extracts.

Figure 3 shows a photograph of olive leaves. Three mixes of extracts: maltodextrin in ratios of 6:1, 4:1 and 1:1 were used for spray drying. A bench scale spray dryer was used to spray dry the combined materials, total solid mass was extracted. The atomizer in the spray dryer had 0.5mm inner diameter.

Figure 3. Photograph of Olive leaves (Ref: www.123rf.com/photo_114124612_olive-leaves-isolated-on-white.html)
The washed leaves and stems of fresh guduchi plant were used to prepare extracts, by mixing with water and two extracts of stems alone were used. Spray Dryer with twin-fluid atomizer co-current at 45 psi in pilot scale was used. The analysis also included storing the SDP at 4 °C, measuring the average moisture content by American Association of Cereal chemist’s method as well. Using the Heinonen method the concentration of the phenolic compounds were found out and the results were expressed as tannic acid equivalents. Morphology of the spray dried Guduchi powder were also studied using the SEM.

The leaf showed less moisture content and less hygroscopic than the stem. The Guduchi plant’s leaf and stem extracts were successfully spray dried at 90 °C. The leaf extracts showed higher percentage of retention of polyphenols as well as antioxidant activity. [8]

Ertan Ermis et. al have the studied the characteristics of proteins extracted from De-oiled sunflower cake. Due to the rise in the population extensively there has been increasing demand of plant protein. The obtained seed cakes were dry and also contained particles of husks. The extract was made by using 9L of salt solution and the HCl solution was used to control the pH until it was maintained at 4.0. Pilot scale spray dryer was used for the proteins extracted from de-oiled sunflower extracts at an inlet temperature of 175℃ and outlet temperature of 80℃. The flow rate of the protein was set to 34mL/min. Proximate analysis was done for the obtained powder and the particle morphology was done by SEM imaging. The Hausner ratio values and the angle of repose were determined to assess the flowability of the powder. The emulsifying properties, oil binding capacity, solubility analysis, wettability analysis, Fourier-transform infrared spectroscopy and differential scanning calorimetry characterizations were also studied for the obtained product. The ground cake which included husks contained around 35% protein, 1.4% of crude fat and little amount of ash. There was a low yield of precipitated protein from the de-oiled sunflower. The microstructure analysis showed that the powder obtained contained particles of various size proportions and had shown irregular surface properties. The flowability and compressibility of the powder was studied to analyse the problems caused during storage, transportation. The SDP showed varied physical and functional characteristics which affected its flowability. Typical angle of repose value was 49± 2° that was found to be suitable for good flowability. The findings complemented the understanding to improve storage, handling and processing behaviour of the powder at industrial level, and also in the formulation of vegan and meat items. [9]

Lina F. Ballesteros et al have studied the encapsulation of the antioxidant properties extracted from spent coffee grounds. Presences of phenolic compounds in the products are important for the functional properties therefore are of huge interest for the chemical, pharmaceutical and food industries. In order to encapsulate the phenolic compounds extracted from the spent coffee grounds (SCG) freeze drying and spray drying processes are generally used. The process of auto-hydrolysis was used for the extraction of the phenolic compounds from the SCG. Encapsulation was carried out using the carrier materials such as arabic gum and maltodextrin. The extracts were subjected to freeze drying and spray drying; moisture content was determined for the freeze dried and spray dried samples. Chemical and structural characterization and antioxidant phenolic compounds characterization of the SCG extract were carried out. The statistical analysis was carried out using Graph Pad prism. The HPLC analysis showed the presence of chlorogenic acid (19.99±3.56 mg/100mL) and sugar derived compounds (12.44±2.29). The structural analysis was done using the FTIR and XRD and the thermal behaviour was studied using DSC and TGA curves. The characterization of the encapsulated samples was carried out by studying the Morphology, structural characteristics and the thermal stability. The efficiency of encapsulation was also studied. In this study it was found that the technique and the coating materials were found to have great influence on the
encapsulation of antioxidant phenolic compounds extracted from the SCG. The freeze-drying using maltodextrin used as coating material was considered to be a good option for encapsulation as it was able to retain 62% and 73% of the phenolic compounds. [10]. Satureja montana L. also known as Winter Savory is a medicinal herb known for its antioxidant, anti-proliferative, anti-inflammatory and anti-HIV-1 activity leading to an increased importance in the pharmaceutical industry.

Senka et. al. have presented their investigations related with the process of spray drying S. Montana liquid extract (details not given here) using maltodextrin particles (available commercially as nutritional product) as a carrier for the powder extract. Carriers are substances which assist in the microencapsulation process and are mixed with the main extract to form slurry.

The Liquid extract of S. Montana was added with varying percentages of maltodextrin and spray dried to analyze various parameters such as bulk density, hygroscopicity, WSI (water solubility index), WAI (water absorption index) and production yield. The extract was also analyzed to obtain the overall content of phenols, flavonoids, essential oils and carvacrol which provide the plants medicinal properties with respect to the amount of maltodextrin used. For powder parameters an increase in Maltodextrin led to decrease in bulk density, increased hygroscopicity, increase in WSI and a decrease in powder WAI. Overall conclusion obtained was that at 10% maltodextrin content added with S. Montana extract provided the highest content of phenols, flavonoids and essential oils [2]. Soybeans (useful contents) possess a certain special phenolic group known as isoflavones which are said to be anti-oxidative in nature. Sandra et. al. has identified the processing parameters needed to obtain highly efficient spray dried soybean extract and its usage as an antioxidant.

Dried soybeans were used in the extraction process. Silicon Dioxide (powder) was used as a drying excipient (carrier) as it showed the best drying performance. Various free radical scavenging tests were performed on the CSE (concentrated soybean extract) and SDSE (spray drying of soybean extract). As a reference the same tests were performed on Quercetin, a well-known antioxidant. Results show that to obtain high nutritional value of the SDSE, selection of the right drying excipient is required.

Another final remark stated that the chemical and antioxidant properties of SDSE were affected by SD temperatures. [11]

Due to its characteristic flavor C. annuum (red chillies) is opted heavily in the culinary industry and food processing industry. It is said to contain antioxidant, antimicrobial and pro-vitamin properties due to the carotenoids and polyphenolic compounds present in it. Andrea et. al. aimed at studying non-aqueous extracts of C. annuum using 3 separate oils and their microencapsulates. Corn, sunflower and Safflower oils were used for the extraction of carotenoids from the C.annuum extract at 3 different temperatures (60,70,80°C) and 2 mixing times (5,10 minutes) after which antioxidant activity of the NAEC (non-aqueous extract of chilli) was obtained using 2,2-azino-bis method.
Microencapsulates were produced using arabic gum and maltodextrin as biopolymers in a spray dryer with the extracts. Antioxidant activity and carotenoid presence of the micro-encapsulated NAEC was determined. The micro-encapsulates where tested for morphology, encapsulation efficiency, mean particle size (SEM), water activity and stability. In conclusion it was obtained that corn oil provided the highest yield during extraction and the microencapsulates obtained using this oil where the most stable.[12]

Yerba Mate is a South American plant consumed for its antioxidant properties. Graciele et. al. have studied the utilization of spray drying to produce microencapsulates of highly concentrated yerba mate extract procured from the freeze concentration process. The impact of maltodextrin fixation (20%, 30%, and 40%) on the phenolic mixes, antioxidant properties, microencapsulation yield, morphology, molecule size, dampness content, water movement, disintegration, hygroscopicity, color and thermal properties were explored. Figure 8 shows the photograph of the plant.

Phenolic contents of SDP of extracts, steadiness of microcapsules at 4°C in 45 days were obtained. An increase in the overall phenol content and antioxidant properties were obtained. Increased presence of maltodextrin in the microcapsules resulted in higher phenolic contents, higher molecule sizes, and longer time taken by SDP to breakdown in water with reduced solubility. Maltodextrin encapsulate had higher heat retention based on color parameters. [13]

Orthosiphon stamineus is a herb widely used to make herbal tea. Sook et. al. studied micro-encapsulation of these leaves by using the whey protein and maltodextrin of polyphenol obtained from them. The extract was spray dried and polyphenol content was gauged using ultra performance liquid chromatography (UPLC), used to separate, identify, and quantify each component in a mixture. Some of the other factors obtained were viscosity, particle size distribution, particle surface morphology and particle moisture content. Figure 9 shows the photograph of the plant.

Results obtained showed that an increase in solid concentration caused an increase in solution viscosity, increase in particle size, decrease in moisture content and decrease in surface denting. The retention of the 3 main bioactive components found (romarinic acid, sinensetin, eupatorin) was observed when least amount of protein was used (0.05 wt. %). Higher retention of bioactive components was also observed at 5.33% maltodextrin content suggesting maltodextrin is a better agent for preservation of polyphenols.[14]

Popularly known as cow’s feet, the leaves of B. forficata are used mainly for their antidiabetic properties as a folk medicine. A.M.daCunha et. al. studied the hypoglycemic activity of dried extract of B. forficata obtained thru 3 different drying methods (over dried, spray dried and wet granulation extract). The extracts were obtained using colloidal silicon dioxide and/or cellulose: lactose mixture as matrix. Spectro-photometric, chromatographic and photo microscopy image analysis was carried out on the dried extracts. The dry extracts obtained were administered to winstar rats to monitor the
hypoglycemic activity after the rats were induced with diabetes using streptozotocin. Figure 10 shows the photograph of the leaves.

**Figure 10.** photograph of B. Forficata leaves

After 7 days the liver was removed from the rat specimens and tissue dried and stored for further research. Results obtained showed that spray drying or oven drying B. forficata extract did not change flavonoid profile or hypoglycemic activity and although the wet granulation extract possessed lower concentrations of extract, the manufacturing properties of the oven dried extract improved using the granulation process.[15]

Guava fruit is a rich source of ascorbic acid and possesses high amounts of vitamin c which is highly beneficial for us. Vaibhav et. al. investigated advanced and refined spray drying techniques used to preserve guava fruit. The fruit juice was concentrated and atomized and then the spray drying process was optimized using RSM. In this paper four response surface models were obtained for the four important parameters selected which are: moisture content, solubility, dispersibility and Vitamin C content with respect to inlet temperature and maltodextrin levels. For moisture content it was obtained those moisture content decreases by increasing inlet temperature of air. For solubility and dispersibility increase was seen with a decrease in additives viz. Maltodextrin. . Figure 11 shows the photograph of the fruit.

**Figure 11.** photograph of guava

Loss in Vitamin C content was reported due to high temperature ranges that could be modified according to need. Optimum condition required could be taken from the response surface models obtained to achieve a specific goal. Superimposition of the various graphs obtained indicated an air inlet temperature level of 185°C and maltodextrin level of 7% to get the optimized spray drying result of guava powder.[16]

### 4. Concluding Remarks

This review paper brings out the versatility and usefulness of spray dryer to synthesize free-flowing micro-globules, with specified characteristics, from the nutrients extracted from many common medicinal herbs. A glimpse into the process of spray drying of an iron based medicinal extract from the leaves of a medicinal herb, and the synthesized spray dried powder, obtained in the authors laboratory also is being reported. The goal of the paper is to bring out the importance of using commonly found medicinal herbs integrated with spray drying process to make them easily available for immunity building purposes against common ailments.

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