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Value addition of *Limonia acidissmia* L.

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Abstract
Wood apple is a unconventional fruit. Fresh, ripe wood apples with hard shell, hardened rind, fairly large and globular shaped with soft, fleshy, yellowish edible pulp were procured from local wholesale market, Hyderabad. Pulp was extracted and the stored for preparing dehydrated powder and murabba. The left over pectin extract was used for preparing jelly. To reap the nutritional benefit and to get market throughout the year many value added products like wood apple jelly, dehydrated powder and murabba were developed. It is also employed in the treatment of diarrohea and dysentery. The fruits are very rich in protein, iron, and calcium and phosphorous. The osmotic dehydrated powder was found to be rich in carbohydrates (61g / 100g) due to sugar is absorbed during osmotic regulation. Negligible growth of microbes was observed in all the wood apple powder, jellies and murabba. All the products can be stored without any deterioration and are consumer acceptable upto three months of storage as per the study.

Keywords: Wood apple, murabba, dehydrated powder, pectin, pulp

Introduction
India is the origin of many tropical fruit plants, most of which are not cultivated commercially but provide a significant nutritive value for rural communitiies. Many tropical fruits are labeled as "underutilized species", which are characterized by the fact that they are locally abundant, but restricted in their geographical dispersion and have a high use value. One of the underutilized fruit species that is of importance in India is wood apple (*Limonia acidissimia*), which belongs to Rutaceae family. It can be planted under almost all conditions of soils and climates (CSIR, 1956) and it bears about 400-800 fruits per annum. It is an evergreen tree that is abundant in Western India and is considered to have great potential as a medicinal plant. Both the pulp and leaves extract are used for a range of purpose (Korikanthimath and Desai, 2005) [1]. Ripened wood apple fruits contain sour, sweet, aromatic and refreshing pulp with an excellent flavor and it is highly valued for its therapeutic values in Ayurveda. These species represent a great opportunity to the local growers to reach special markets in which the consumers are interested in processed exotic products as well as richer sources of antioxidants and nutrients capable of maintaining health and preventing degenerative diseases. However, not many studies have focused on the effect of minimal processing, irradiation and secondary processing on the antioxidant properties in varieties of semi arid fruits. Data on the effect of processing on natural antioxidants in the fruit, can be utilized to promote processing, thereby increasing the utilization, shelf life, consumption and its promotion as health food. (Weimin zhang *et al*., 2009) [2]. Wood apple is a dry land fruit, which is a nutritious one; it is rich in natural acids, such as oxalic, tannic, mallic and citric acid. It is a source of calcium, phosphorus, iron and vitamins A, B and C. Leaves of the plant contain essential oil, used as astringent and the wood apple gum is used as an ointment, to calm irritated skin (Chowdhury *et al*., 2008) [3]. Besides the name "wood apple," it is also referred to as elephant apple, monkey fruit, curd apple, Keth bel, golden apple, stone apple, etc. It is a well-known fruit which contains several known and unknown medicinal properties and hence is viewed as one of the most valuable medicinal plants in India (Jayakumar and Geetha, 2012) [4]. The pulp in ripened fruit is about 70% of total weight and seeds are embedded in the pulp. It contains about 70% moisture, 7.3% protein, 0.6% fat, 1.9% mineral matter, 2.3% acidity, 7.2% sugars, 0.07% iron, 0.08% phosphorus and it is a rich source of riboflavin (77 mg/100 mg) and calcium (0.17%). The pulp contains 3 to 5% of pectin (16% yield on dry-weight basis) (Chundawat, 2003) [5]. Wood apple is a cheap, highly nutritious and seasonally available fruit that can be preserved for human consumption throughout the year.

Young bael leaves are used in salads in Thailand. Indonesians eat the pulp of the ripe fruit with palm sugar at breakfast. In India pulp is consumed with sugar or jaggery. It is used for making chutney and pickles or is blended with coconut milk and palm-sugar syrup and taken as a beverage. Wood apple pulp is excellent for making jelly (Jayakumar and Geetha, 2012) [4].

General Objectives: To procure raw material and process wood apple into various products and to evaluate its microbiological, physicochemical and organoleptic properties.

Specific Objectives

1. To standardize wood apple powder, murabba and jelly.
2. To evaluate physico-chemical and microbiological characteristics of the wood apple products.
3. To evaluate sensory characteristics of the wood apple products.

Review of literature

Fruits and vegetables are important supplements to the human diet. In India the processing industry at present is utilizing less than two per cent of the total fruits and vegetables produced as against 40-80% in developed countries (Srivastava and Kumar, 2002) [8] Wood apple belongs to the family Rutaceae. It is a tropical deciduous species, native to India and Srilanka.

The products such as jelly, chutney, jam, nectar and beverage are prepared from the pulp of this fruit. It is also employed in the treatment of diarrhea and dysentery. The fruits are very rich in protein, iron, calcium and phosphorous (Rao *et al*., 1989) [9]. According to Srivastava and Vastya (1986) [10], wood apple beverage produces cooling effect in the same way as that of bael.

Physico-chemical composition of wood apple

Singh *et al*. (2000) [11] studied the physico chemical characteristics of wood apple fruit obtained from four lines and they reported that there was great variability in the physical characteristics of fruits. Variations in the content of certain chemical constituents i.e. moisture, reducing sugar and total sugars were also significant.

The results indicated that Shakulpurwa line has better potential for processing because of its higher content of edible portion with minimum number of seeds and the lowest content of seed and fibre and it consists moisture (74.04%), T.S.S (16.27%), acidity (3.12%), reducing sugars (6.47%), non-reducing sugars (2.93%), pectin (2.07%), ascorbic acid (6.11 mg / 100 g),calcium (93.45 mg / 100 g), phosphorous (241.24 mg / 100g) and iron (0.47 mg / 100 g.)

Extraction of Pulp

The extraction of pulp from ripe bael fruit by addition of water equal to pulp (with seeds and fibre) adjusting the pH to 4.3 with citric acid and heating at 800C for 1 min. was described. The application of heat not only inactivated the enzymes but also helped in dissolving the mucilage uniformly to provide a homogeneous pulp (Roy and Singh 1979) [12].

Wood apple jelly

Poonam Aggarwal *et al*. (1997) [13] prepared coloured jelly using three grape varieties and it was observed that all the three varieties separately as well as in combination was unable to form a desirable jelly. Therefore, grape juice was mixed with guava extract in the ratio of 20:80 and the blend had excellent jelly setting.

Jadhav *et al*. (2004) [14] used raw and ripe karonda fruits for the preparation of jelly, jam, R.T.S beverage, squash and sweet chutney. Among them, raw karonda jelly recorded the highest organoleptic score.

Singh *et al*. (2004) prepared jelly from barhal fruit by blending flesh-water in 1:1 ratio and boiling for 5 min. That extract was filtered to obtain pectin. To pectin extract, three-fourth part of sugar added and cooked to end point (1050C).

Murabba

Koli *et al*. (2004) [15] prepared sapota murabba from kalipatti cultivator of sapota and standardized the process for preparation of sapota murabba and the levels of murabba ingredient were also standardized. It contains sugar (1000g), pectin (10g) and citric acid (6g) per one-kilogram pulp. Jadhav *et al*. (2004) [14] used raw and ripe karonda fruit for the preparation of different processed products like murabba, jelly, sweet, chutney, squash an R.T.S beverage and given a detailed products prepared, and murabba was prepared as per the specifications of F.P.O (1955). Shalini Gaur *et al*. (2005) dealt with optimization of selected process parameters during manufacture of murabba from underutilized fruits: ber and loquat and they reported that murabba prepared from the pre treated ber, the pulp being adjusted to 3.4 pH and pulp: sugar ratio of 1:0.8 was found to be most acceptable and loquat murabba prepared from the pretreated pulp, adjusted to pH 3.2 and pulp: sugar ratio of 1:0.9 was found to be most acceptable.

Dehydrated Powder

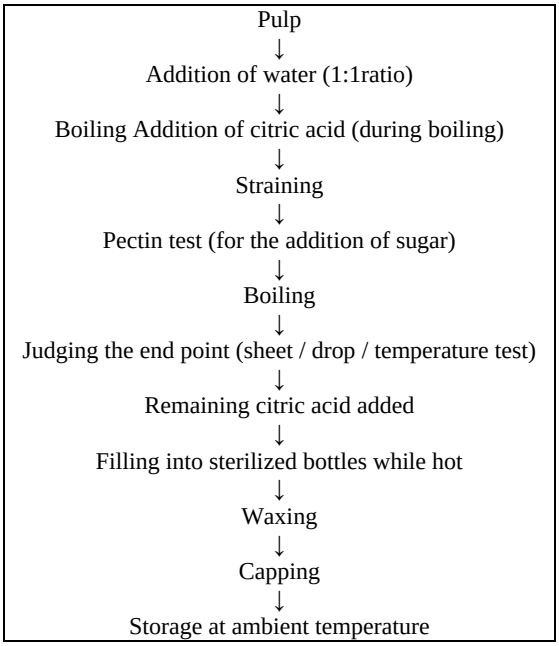
Jayakumar and Geetha (2012) [4] reported that the wood apple is high in oxalic, mallic, citric and tannic acids. It's a good mixture of vitamin and minerals including calcium, iron, phosphorous, carotene, thiamine, riboflavin and niacin. Elemental analysis of some herbal plants has been performed using the techniques of neutron activation analysis and Atomic Absorption Spectroscopy 19 (AAS). The elements Mn, Na, K and Cl concentration has been estimated by Neutron Activtion Analysis and a high purity germanium detector coupled to a multichannel analyzer, while the elements Ca, Cr, Co, Cu, Fe, Pb, Zn, Ni, Cd and Hg were analyzed by AAS using a Perkin Elmer 3100 instrument. The elements such as Na, Mg, K, Ca, Mn, N and Cl were detected in tested plants

Materials and Methods

Jelly

Ingredients: Pulp, Pectin, sugar, citric acid and water.

Method

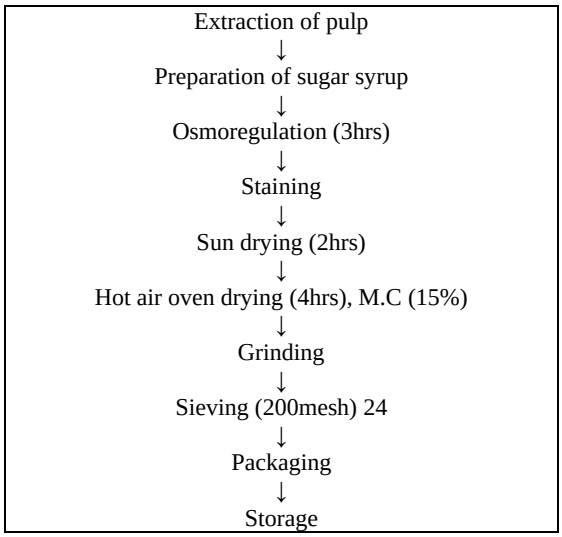


Flow -chart for processing of wood apple jelly

Osmotic Dehydrated Powder

Ingredients: Pulp powder, sugar, water

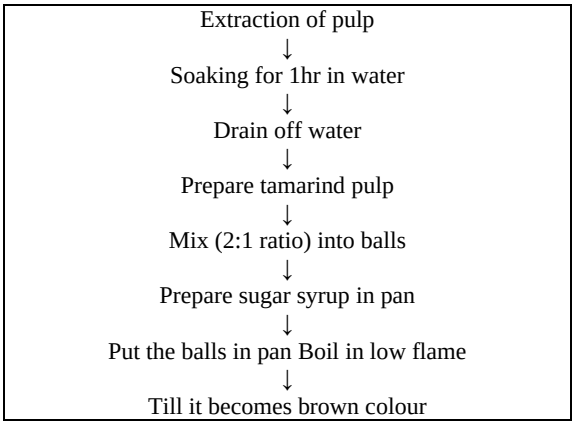
Method



Flow -chart for processing of wood apple Dehydrated powder

Murabba
Ingredients: pulp, water, tamarind pulp, sugar, oil.

Method



Flow -chart for processing of wood apple murabba

Physiochemical Parameters
1. Water absorption capacity for powder
About 1.05-1.36 g powder was mixed with 10 ml distilled water in a test tube. It was then shaken for 1 min and allowed to stand for 30 min at 24 ℃ before it was centrifuged at 2000 RPM for 25 min. The retained water in a test tube after discarding the excess water was measured

$$\frac{final - initial}{initial} x\ 100 = \frac{3.5 - 1.5}{1.5} x\ 100 = 133.3\%$$

2. Synerisis for Jelly
In the process of storing jellies, an effect called syneresis occurs, which appears as a separation of low-molecular-weight liquid on their surfaces

$$\frac{water\ loss\ from\ jelly}{weight\ of\ jelly} x\ 100\ = \frac{4}{100} x\ 100\ = 4\%$$

Total soluble solids
Principle
Refractometers are designed to measure the refractive index of a solution. The Brix scale is based on a sucrose and water solution. However, since most sample contain substances other than sugar- such as salts, minerals and proteins-the Brix percentage represents the total concentration of all soluble solids in the sample.
The total soluble solid content was determined in terms of ^{0}Brix using refractometer (model - Digital hand-held "Pocket" Refractometer of 0-100 range).

PH
Principle
A pH meter is essentially a voltmeter with high input impedance which measures the voltage of an electrode sensitive to the hydrogen ion concentration, relative to another electrode which exhibits a constant voltage. The key feature of the pH-sensitive electrode is a thin glass membrane that's outside surface contacts the solution to be tested. The inside surface of the glass membrane is exposed to a constant concentration of hydrogen ions (0.1 M HCl).
pH of the fresh pulp and the products was measured using digital pH meter (101 E Deluxe Model).

Acidity
Principle
The presence of acid in a solution can be identified by their effects with acid base indicators such as methyl orange and phenolphthalein. These indicators tell us whether a substance is acidic or basic by change in color. The color of the phenolphthalein solution changes to light pink to dark pink by addition of dilute 0.1N NaOH solution the effect of a base is nullified by the presence of acid in the sample solution.
Acidity of the fresh pulp and products was measured as per the procedure give by Ranganna (2005) by titrating the sample against 0.1N sodium hydroxide solution using phenolphthalein indicator.

Moisture
Principle
Removal of moisture from the sample and then a weight determination of the solids remaining to calculate the moisture content. Non-water volatiles can be lost during drying, but their loss is generally a negligible percentage of the amount of water lost. Moisture of the fresh pulp and the products was measured by using standard AOAC method (2016).

Carbohydrates
Principle
Carbohydrates react with 9, 10-dihydro-9-oxoanthracene (anthrone) under acidic conditions (concentrated sulfuric acid) to yield a blue-green color. The reaction mixture is heated in boiling water for 15 min and then allowed to cool in the dark (for color formation, 20-30 min) before measuring the absorbance at 630 nm Carbohydrate content was determined by Anthrone method of Raghuramulu *et al.,* (1983).

Protein
Principle
The nitrogenous compounds of the material to be tested are converted into ammonium sulphate by boiling with con. H2SO4. It is subsequently decomposed by addition of excess of alkali and the liberated ammonia absorbed into a boric acid solution containing Bromocresol green indicator by steam distillation. Ammonia forms a loose compound, ammonium borate, with boric acid, which is titrated directly against

standard hydrochloric acid. Protein content was estimated by Kjeldahl AOAC method (2016)

Fat

Principle

Fat is estimated as crude ether extract of the dry material.
Fat content was determined by Soxhlet method AOCS (1990).

Crude fiber

Principle

The sample is allowed to boil with dilute H_2SO_4 (0.255N) and dilute sodium hydroxide (1.25%) and the remaining residue after these digestions is taken as crud fiber. Crude fiber content was estimated by AOAC method (2016).

Total ash

Principle

When foods and food products are heated to temperatures of 500 ^{0}C-600 ^{o}C the water and other volatile constituents are evolved as vapors and the organic constituents are burned in the presence of oxygen of the air to carbon dioxide and oxides of nitrogen and also eliminated together with hydrogen as water. The mineral constituents remain in the residue as oxides, sulphates, phosphates and chlorides and this in organic residue constitutes the ash of food products. Total ash content was estimated by AOAC method (2016).

Microbial examination of the products

Total bacterial counts

For estimating population in different samples, dilution plate method was followed. (Cruikshank *et al*., 1975) [18].
One gram of sample was thoroughly mixed in 9 ml of sterile saline water, from this, 1 ml of sample was transferred through a sterile pipette to a screw cap tube containing 9 ml sterile saline water, and this gives a dilution of 10^2. Similarly, serial dilutions were made. 1 ml. of the sterile serially dilute of sample was placed in the sterile petri dish to which cooled plate count agar medium was added and mixed thoroughly with the suspension and then allowed to set and then incubated at 28 + 2 ^{0}C for 48 hrs. Individual colonies were counted and multiplied.

Yeast and Molds

Dilution plate method is used for yeast and mold content (Cruikshank *et al*., 1975) [18]. Potato dextrose agar medium was used for estimating the fungal population. Samples were diluted in the sterile saline after plating.

Sensory Evaluation

The sensory evaluation of developed products i.e. jam, squash and chutney was carried out by using five point hedonic scale with trained panel members from Post Graduate Research Centre who had previous experience in sensory evaluation of different food products.
Judgement was made through rating products on a 5 point Hedonic scale with corresponding descriptive terms ranging from point 5 'like extremely' to 1 'dislike extremely' (Amerine *et al.*, 1965).
Wood apple products were scored for different quality attributes like as color, flavor, taste, texture, consistency and overall acceptability. The best acceptable product was selected for further studies. Sensory evaluation was conducted on 0day, 30th day and 60th day of storage.

Results and Discussion

Sensory Evaluation of Developed Products

Sensory evaluation offers an opportunity to obtain a complete analysis of the various properties of food as perceived by human sense. Sensory evaluation is important as it helps in evaluating new products developed, which also provide quality measure and production control (Bongirwar, 1999) [17].

Table 1: Organoleptic scores of developed wood apple products for different parameters

Parameter	Dehydrated Powder	Jelly	Murabba
Color and Appearance	9.0 ± 0.42	8.0 ± 0.64	6.4 ± 0.35
Texture	7.2 ± 0.43	8.4 ± 0.34	7.4 ± 0.72
Taste	8.9 ± 0.55	9.4 ± 0.32	5.1 ± 0.66
Flavor	8.2 ± 0.42	7.2 ± 0.16	8.5 ± 0.35
Mouth feel	7.5 ± 0.46	8.0 ± 0.43	7.4 ± 0.45
Overall Acceptability	8.2 ± 0.42	7.8 ± 0.45	7.7 ± 0.53

Values are expressed as Mean ± Standard deviation

Results of the sensory evaluation showed that there were negligible changes in developed products over the period of storage.

Color and Appearance

The mean sensory score for color and appearance was highest for powder and lowest for murabba while the jelly scored in between these two products. According to mean scores of panelists, jelly had best acceptable color and appearance compared to other products.

Texture

Texture is the sensory and functional manifestation of the structural, mechanical and surface properties of foods detected through the senses of vision, hearing, touch and kinesthetic. Texture is how the food feels in your mouth, hard, soft, crunchy, smooth etc. Texture is the feel of anything on our senses.
The mean sensory score for texture was highest for jelly and lowest for murabba and powder.
According to mean scores of panelists, jelly had evenly spreadable texture, murabba had a coarse texture with bigger particle size and powder was too thin.
Therefore jelly had best acceptable texture compared to other products.

Taste

Taste is the sensation produced when a substance in the mouth reacts chemically with receptors of taste buds**.**
The mean sensory score for taste was high for jelly and low for murabba. Taste of jelly is more acceptable than the powder and murabba. According to mean scores of panelists, jelly had best acceptable taste compared to other products.

Flavor

Flavor is the sensory impression of a food or other substance, and is determined mainly by the chemical senses of taste and smell. It is a substance that gives another substance flavor, altering the characteristics of the solute, causing it to become sweet, sour, tangy, etc.
The mean sensory score for flavor was lowest for jelly and highest for murabba.
According to mean scores of panelists, murabba had best acceptable flavor compared to other products.

Mouth feel

Mouth feel is a product's physical and chemical interaction in the mouth, an aspect of food rheology. It is a texture of a substance as it is perceived and the tactile sensation a food gives to the mouth.

The mean sensory score for mouth feel was highest for jelly due to its uniformity of chewing and was lowest for murabba. Due to graininess of murabba and bitterness of powder the products showed an adverse effect on mouth feel. According to mean scores of panelists, jelly had best acceptable mouth feel compared to other products.

Overall Acceptability

The mean sensory score for overall acceptability was highest for powder and lowest for jelly.

The evaluation suggested that the wood apple powder was most acceptable as it did not affect the quality and also improved the product in terms of taste, texture and flavor.

Chemical Parameters for Wood Apple Pulp and Powder

Values are expressed as Mean ± Standard deviation

Ash

The ash value is a measure of the amount of added minerals. Natural ash content is due to the minerals like calcium, phosphorus and iron. Ash content of a foodstuff represents inorganic residue remaining after destruction of organic matter (Rao *et al.,* 2003) [9]. Ash content was high in the powder than in the pulp.

Protein

The protein content was higher for powder than in the pulp i.e. 13.8 and 5.7 respectively.

Carbohydrates

The carbohydrate level was high in the powder than in the pulp. This was mainly due to the addition of sugar during Osmoregulation which increased the carbohydrate content in powder.

Fiber

Among the two samples the higher crude fiber content was found in powder than in the pulp.

Fat

Among the two samples, the higher fat content was found in powder than in the pulp.

Titrable acidity

Acidity is the measure of shelf-life of the product. Titrable acidity was studied to ensure physico-chemical changes during preparation (Sandhu *et al.,* 1998) and during storage (Kalra *et al.,* 1985). Fruit products are being effectively preserved at low pH. pH estimation was done in order to find out whether a low pH (Sindhu *et al.,* 1984) was maintained throughout the study which could be an effective preservation. Titrable acidity was found to be higher in the powder than in the pulp.

Table 2: Chemical parameters of wood apple pulp and powder.

Parameters	Pulp	Powder
Moisture (%)	67.0 ± 0.53	7.20 ± 0.64
Protein (%)	5.70 ± 0.25	13.8 ± 0.365
CHO (%)	15.7 ± 0.85	61.0 ± 0.45
FIBRE (%)	4.7 0 ± 0.4	7.01± 0.81
Ash (%)	5.30 ± 0.26	6.80 ± 0.325
FAT (%)	1.60 ± 0.45	4.10 ± 0.65
Titrable acidity	3.20 ± 0.35	4.60 ± 0.34

Summary and Conclusions

- Wood apple is rich in vitamins C and A, and therefore it could be used to treat scurvy or liver problems. Wood apple has anti-diabetic and antioxidant potential. The antioxidant compounds in the wood apple fruit was helpful in preventing the diseases associated with oxidative stress and infectious diseases.
- Wood apple murabba were prepared using different pulp concentrations and sugar concentrations.
- The prepared wood apple products were analyzed monthly for physico-chemical and microbiological parameters. Organoleptic evaluation was done at 45 days interval.
- PH remained stable throughout the storage period in wood apple powder, jellies and murabba. However, a slight decline in pH was observed in wood apple products, which remained statistically non-significant.
- Total soluble solids remained stable during storage period of prepared products. However, a slight decline in TSS was observed in wood apple murabba, while TSS was increased slightly in wood apple jams and jellies, which remained statistically non-significant. Acidity remained unchanged practically throughout storage in all wood apple products. However, there was a slight decline in acidity was observed, which remained statistically non-significant.
- Reducing sugars increased significantly in all products, as the storage period increased.

  As the storage period increased, the total sugar content remained stable in wood apple jelly whereas, decrease in total sugars was observed in wood apple murabba with the increase in storage period.
- All the wood apple murabba were found suitable and ranked good in their organoleptic quality. However T_5 with 20^0 Brix and 30 per cent pulp scored the highest. In jelly all the treatments were found acceptable. Negligible growth of microbes was observed in all the wood apple powder, jellies and murabba.
- All the products can be stored without any deterioration and are consumer acceptable upto three months of storage as per the study.

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