

Development of Noni
(Morinda citrifolia L.)
based Nutraceuticals for Health Security

Dr. P. N. Satwadhar

Head, Department of Food Trade and Business
Management College of Food Technology Vasantnao Naik Marathwada Krishi Vidyapeeth
Parbhani - 431 402. Maharashtra. India



World Noni Research Foundation

12, Rajiv Gandhi Road, Perungudi, Chennai – 600 096, India

Phone : 91-44-490 11 111 Fax : 91-44-490 11 149

E mail : mail@worldnoni.net Visit : www.worldnoni.net

December, 2015

Published by

Prof. P. I. Peter
Chairman
Noni BioTech, Chennai, India

Edited by

Dr. P. Rethinam
Dr. T. Marimuthu
Dr. K.V. Peter

Author

Prof. P. N. Satwadhar

Citation

Satwadhar P. N. 2015. Development of Noni (*Morinda citrifolia* L.) based Nutraceuticals for Health Security. WNRF Technical Bulletin-17, World Noni Research Foundation and College of Food Technology Vasanthrao Naik Marathwada Krishi Vidyapeeth, India, p.41

Printed at

Reliance Printers
9, Sardar Patel Road, Adyar, Chennai - 600 020

Contents

No.	Particulars	Page No.
	<i>Foreword</i>	i
	<i>About the Project</i>	iii
	<i>Preface</i>	v
1.	Introduction	1
2.	State of knowledge	2
3.	Objectives	3
4.	Experimental details & Findings	3
5.	Summary and conclusion	38
	References	40

Foreword

I am happy to write a foreword to this Technical Bulletin which is the culmination form the final report of the project "Development of Noni (*Morinda citrifolia* L.) based Nutraceuticals for Health Security" funded by World Noni Research Foundation. I had opportunities to closely watch the whole process of research work carried out through skilled, thoughtful and well designed investigations by Dr. P. N. Satwadhar form College of Food Technology, Vasantao Naik Marathwada Krishi Vidyapeeth, Parbani, Maharashtra.

The project aimed at developing and standardizing the technology for production of Noni fortified protein rich powder, Noni toffee, Noni cookies and Noni leaf tea and to evaluate the final products. The Principal Investigator could come out with such products that have the potential for commercialization.

I congratulate the author for his unstinted efforts taken to bring out this useful technical bulletin.

Chennai
December, 2015


(Kirti Singh)
Chairperson

About the Project

World Noni Research Foundation (WNRF), Chennai, is committed to undertake research and development on Noni with the ultimate objective of human wellness, nutrition, health, prosperities and empowerment. Noni is assuming importance in recent years as it has potential to develop safe plant based drugs.

Noni was not quite recognized as a fruit of any special importance in our life in whatever manner but I proudly put forth that the intense and focused attempts of WNRF proved to be pioneering and vital in showing the extraordinary properties that the fruit possesses in curing a wide range of health problems. This potential of Noni has made the dream of achieving the above said objectives of the Foundation as a reality. If the products that are commonly and routinely used by the consumers are fortified with Noni, they will help in improving the health of the consumers thereby providing a health security at low cost. The project sanctioned to Dr. P. N. Satwadhar, the Principal Investigator was aimed to achieve this objective so as to explore the possibilities of developing noni based food products that could be commercialized.

Dr. P. N. Satwadhar could fulfill the objectives through his meticulous planning and execution of the project. We had opportunities to taste his final food products like Noni Cookies, Noni Toffees, Noni leaf tea etc. I congratulate the investigator for his earnest attempt to develop noni based products and a useful technical bulletin which is the culmination from WNRF funded project.

Chennai
December, 2015



(P. I. Peter)

Chairman, Noni BioTech

Preface

Noni (*Morinda citrifolia* L.) fruit is a Fruit of 21st Century, considered as Panacea for remedies due to its high nutraceutical contents. The cultivation of this fruit is extensively done by using tissue culture technique which results into increased yield of fruit.

Noni has tremendous use as a functional food as well as food supplement. Therefore, the standards and regulations for noni based nutraceuticals are utmost essential as there is great demand of Noni in Nutraceutical food. Among the minor fruit utilized, Noni fruit have been found suitable for preparing excellent quality products of Noni at household level. E.g. pickle, herbal jam, syrup, sauce, toffee and fermented products such as cider and wine as appetizers. Nevertheless, Noni fruits are highly perishable and hence, a protocol for post harvest management to reduce spoilage, thereby retention of quality is highly needed.

The need of an hour is to convert this fruit into value added functional food products which will fetch a greater price and value to the cultivars as well as processors. Further, the standardization of post harvest technology (PHT) and value addition of this magic fruit needs to be critically assessed to retain its nutraceutical content in the final food product. In this regard it is imperative to carry studies on harvesting, indices, harvest techniques, precooling, sorting, grading and suitable packaging containers should be developed. Moreover, studies on storage at farm level and cold storage should be conducted to determine optimum temperature, relative humidity and storage period.

Owing to this, World Noni Research Foundation sponsored a Research project to College of Food Technology, VNMKV, Parbhani for opening new avenue in utilizing Noni fruits in preparation of nutraceutical and functional foods. Further, the studies were taken on retention of bioactive components which imparts Nutraceutical values to the Noni products. However, the clinical studies must be conducted to correlate Noni as Nutraceutical food.

It gives us immense pleasure to place my sincere thanks to Hon'ble Dr. Kirti Singh, Dr. P. I. Peter, Dr. K. V. Peter, Dr. Marimuthu and all other members of RAB for funding this project. I wish to place on record sincere thanks to Dr. K. P. Gore, Hon'ble Vice-Chancellor, VNMKV, Parbhani for his encouraging support and facilities for completing technical bulletin. We are especially thankful to Dr. S. S. Kadam, Former Vice-Chancellor, VNMKV, Parbhani for providing scholastic guidance towards successful completion this project with fruitful results.

We are also thankful to Dr. V. S. Shinde, Director of Instructions and Dean, VNMKV, Parbhani and Associate Dean & Principal, College of Food Technology, Parbhani for providing necessary facilities and worthy suggestions for the implementation of the scheme.

I sincerely express my gratitude to Dr. G. B. Khandagale and Dr. G. R. More, Former Directors of Research, VNMKV, Parbhani for their scholastic support. I would like to thank all the academic and non-teaching staff members for their direct and indirect help for conducting this esteemed research project.

(Prof. P. N. Satwadhar)

1. Introduction

India today is being known as young country due to heavy populations of youngsters. The present young generation being education, is concern with the health not just by traditionally driven ethics but also by the scientifically based justifications. The youngsters are having Omni-access to internet which facilitates easy browsing of information and global health trends. Urban Indians today are not just satisfied only with food that merely tastes good, but the trends are heading towards foods with health benefits.

Every traditional Indian knows some or more details about the food with medicinal values. Thought this knowledge is not technologically driven, but the traditional and conventionally proven recipes of food are still being commonly considered to design food for patient or for specific health disorder. Much of these traditional food formulations are also based even on superstition and it is difficult to authenticate them as a functional food without scientific background.

“Food as Medicine” consumers strongly believe that foods can be used to reduce their use of drugs. They also strongly agree that foods contain active components that improve long-term health. India’s share in global nutraceutical market is only 0.9%. Besides, functional foods contain larger profit margins than conventional foods (30 to 500 percent higher). Considering the huge growth potential of the Global and Indian Nutraceutical industry, India can capitalize on consumers’ interest in functional food by considering the major research in this area and developing the functional food from the sources which has traditionally proven medicine value such as Noni (*Morinda citrifolia* L.).

Noni (*Morinda citrifolia*, L.) popularly known as Indian Noni or Indian mulberry is grown in Andaman and Nicobar by tribes. Noni fruits were traditionally being utilized as food and medicine. In the main land of India it is found along the coastal areas of Kerala, Karnataka, Tamil Nadu and many other places. Noni is termed as “*Ayushbka*” (meaning “longevity”) in ancient Indian practice *Ayurveda*. Traditionally it is being known by various names under different locations including *Baratundi* (Maharashtra), *Nuna*

or *Manjanathi* (Tamil Nadu), *Bandamaddi* (Andra Pradesh), etc. It is also called as Indian Mulberry. Noni juice is in high demand in alternative medicine for different kinds of illnesses such as arthritis, diabetes, high blood pressure, muscle aches and pains, menstrual difficulties, headaches, heart disease, AIDS, cancers, gastric ulcer, sprains, mental depression, senility, poor digestion, arteriosclerosis, blood vessel problems, and drug addiction.

Research Investigations revealed that Noni helps cells regenerate and function more normally, may prevent development of various disorders and works optimally in conjunction with other antioxidants, effective against fungus, parasites and several harmful bacteria, is a natural antiseptic, appear to retard tumour growth by stimulating the immune system, has analgesic effect and also arrests the growth of RAS cancerous cells.

Noni does not find any value as a plant or plant part in urban India. However, the increasing interest, chain marketing, research and results are driving noni value to proliferating heights. It is now a day available all around India in almost every Medicinal store in the form of Noni Juice. Generally, it is available in pure form or mixed with aloe vera juice. The consumption of Noni is mostly limited to the patients suffering from cancer and general weakness.

While extensive research have been done on medicinal properties of Noni, the project for development of Noni based Nutraceuticals and functional foods has not done. Hence, the present investigation was planned to provide a baseline for development of Noni based Nutraceuticals for Health Security.

2. State of Knowledge

Despite a rapidly growing number of scientific publications on Noni fruit, the current state of knowledge is still far from being satisfactory. Utilization of Noni fruit in preparation of Nutraceuticals and functional foods is still in infant stage only. Chandra (2010) made some attempts to prepare juice, jelly, jam, pickles *etc* using the noni fruits.

3. Objectives

1. To study physical and morphological characteristics and chemical analysis of Noni fruits
2. To develop and standardize the technology for production of Noni fortified Protein Rich Powder, Noni Toffee, Noni Cookies and Noni Leaf Tea
3. To carry out sensory evaluation of Noni products

4. Experimental Details & Findings

The project was aimed to prepare different nutraceutical products from Noni Fruit, pulp and juices. The experimental methods adopted in preparation of nutraceutical foods from Noni Fruits are summarized under following suitable headings.

1. Noni Fruit Pulp Extraction

The method for the Noni fruit pulp extraction was adopted from Monograph on Noni (Kulkarni *et al.*, 2007), as follows.

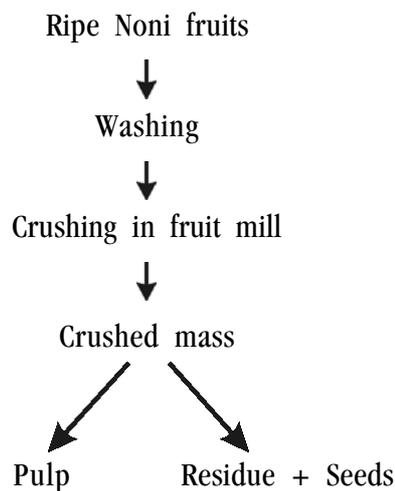


Fig. 1: Flow chart for Noni fruit pulp extraction

2. Enzymatic Liquefaction of Noni Fruit Pulp

The method for the enzymatic liquefaction of Noni fruit pulp was adopted from Monograph on Noni (Kulkarni *et al.*, 2007), as follows :

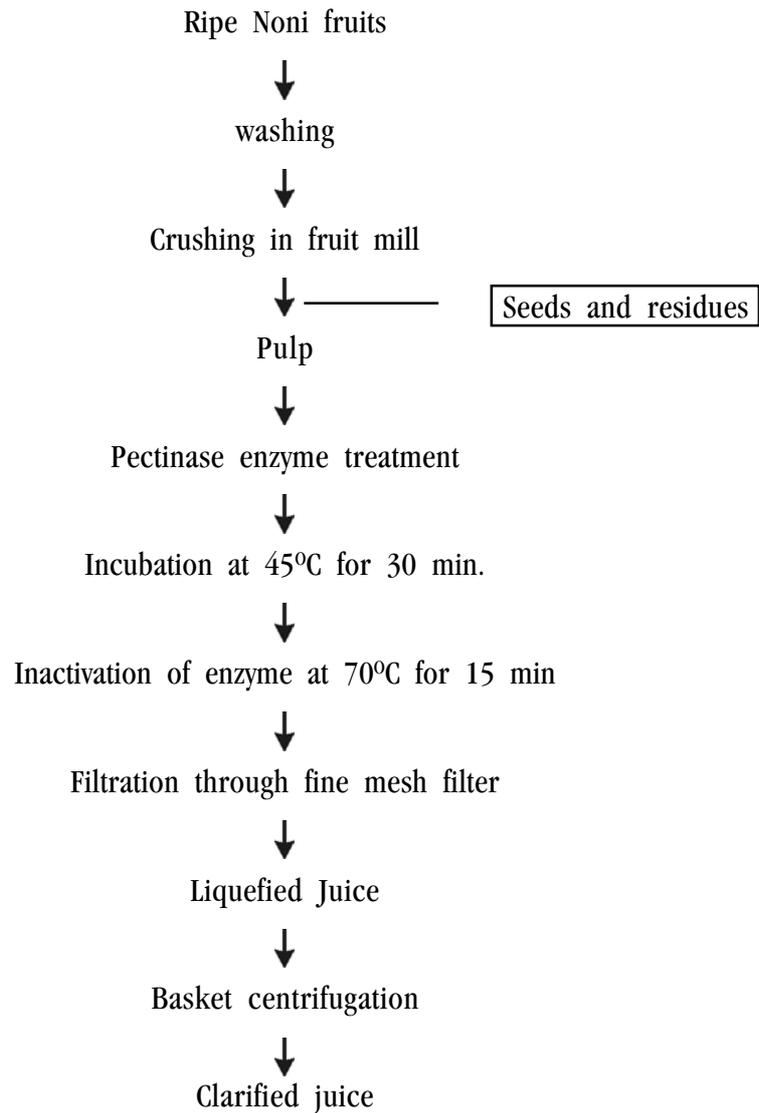


Fig. 2: Flow chart for enzymatic liquefaction for Noni fruit pulp

3. Development of Noni Fruit Toffee

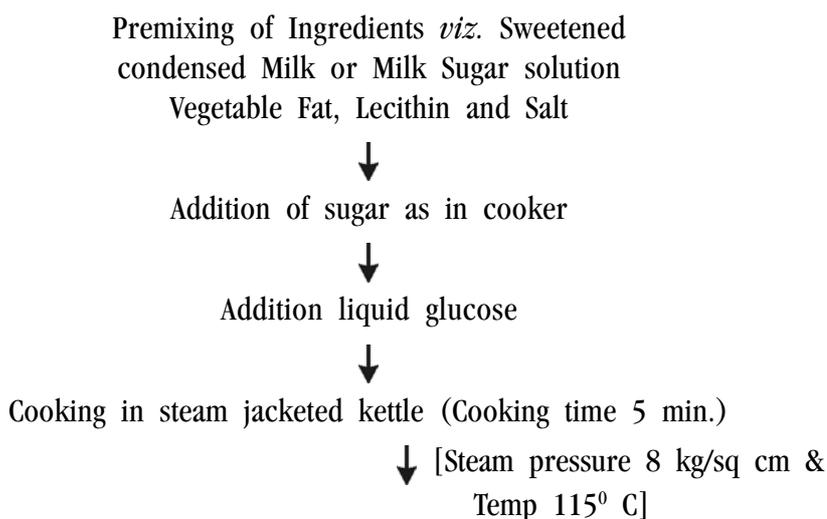
Noni fruit toffee can be prepared by using Noni pulp at the rate of 12 per cent and 14 per cent with other generic ingredients of toffee. Similar trials of Noni fruit toffee preparation were carried out in collaboration with M/s. Makson Pharmaceuticals (I) Pvt. Ltd., Surendranagar (Gujrat).

3.1. Recipe for Noni Fruit Pulp fortified Toffee

3.1.1. the constituents for the toffee in given below

S.No.	Ingredient	Quantity (%)
1	Sugar	28.80
2	Liquid Glucose	48.30
3	Fat (HVF)	9.0
4	Milk Powder	8.66
5	Water	8.7
6	Noni Pulp	12 and 14
7	Lecithin	0.4
8	GMS	0.5
9	Flavours	0.08

3.1.2 Production Procedure of Noni Toffee



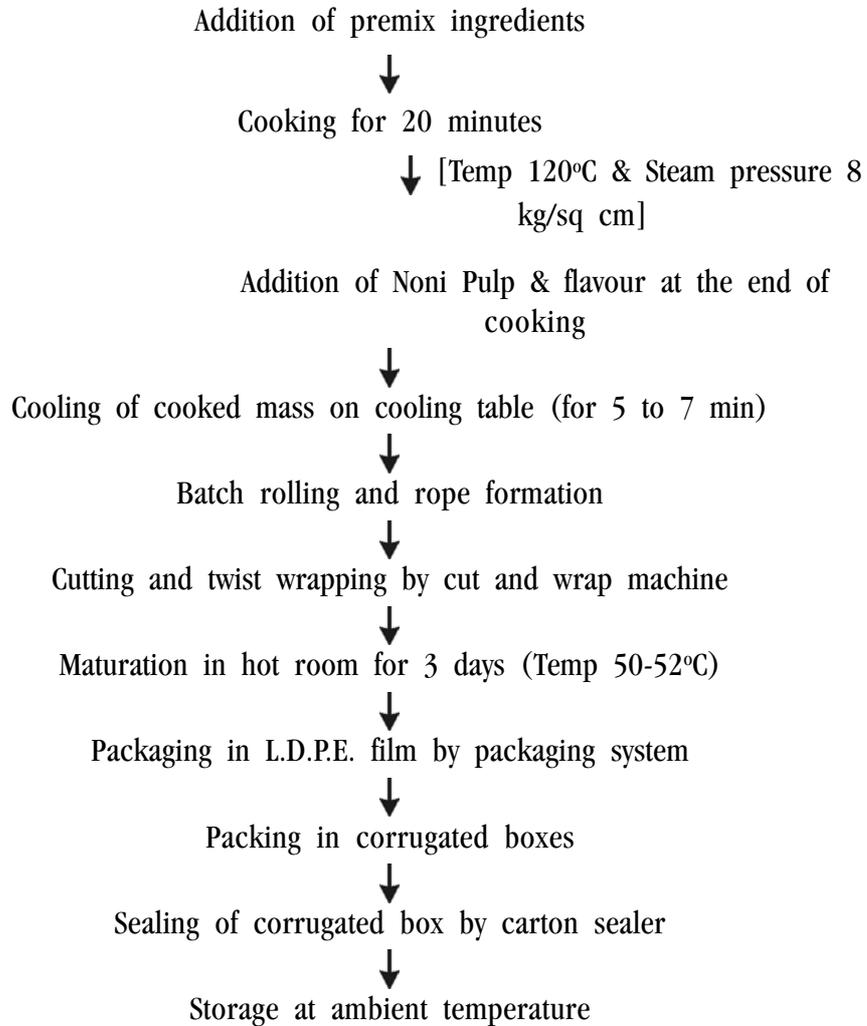


Fig. 3: Flow chart for preparation of Noni Toffee

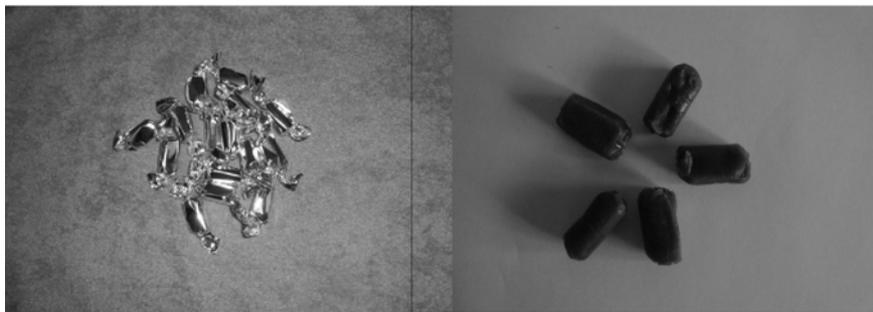


Fig. 4: Noni Toffee

In order to optimize the level of incorporation of Noni pulp in manufacturing of nutraceuticals toffee, different trials with varying concentration *viz.* 12, 14 and 16 per cent of Noni pulp incorporation were carried out.

4. Preparation of Noni Powder

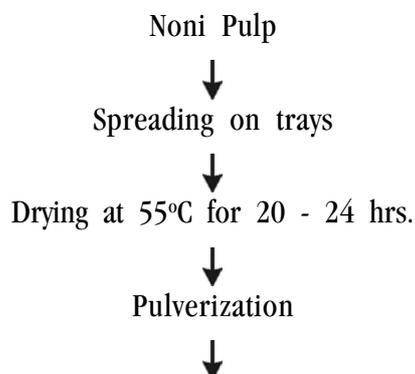
The efforts have been made to prepare Noni powder from the Noni pulp by different drying methods *viz.*, Cabinet, Spray & Freeze drying method with standardization of drying conditions. As a part of development and standardization of technology for production of Noni fortified protein rich powder, studies on powder preparation were carried out.

4.1 Cabinet drying of Noni pulp for powder preparation

Cabinet drying is very simple, easy and suitable economical method for any type of fruit powder production. The pulp of Noni fruit is having large number of bio-active components as nutraceutical, therefore temperature of drying should be within feasible limit to control the losses of nutraceutical so that maximum bio-active components could be retained in powder.

4.1.1 Standardization of process for the preparation of Noni powder by Cabinet drying

During investigation due care was taken to control various variables which affects the quality and the degradation of bioactive components such as temperature and period of drying. The procedure followed during the cabinet drying of Noni fruit pulp is summarized in following flow sheet (Fig. 5).



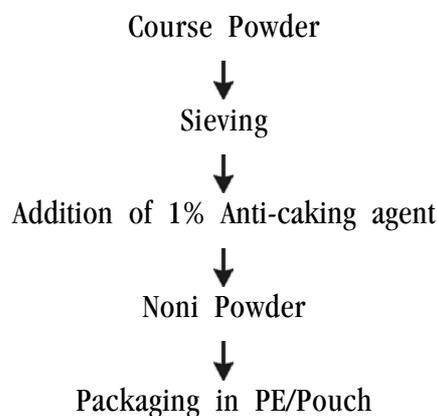


Fig. 5: Flow chart for Preparation of Noni Powder by Cabinet drying

Efforts have been made to standardize the drying parameters of cabinet drying method for Noni pulp drying to convert it into powder of free flowing nature. It was found that acceptable quality powder was obtained at 55°C temperature for a drying period of 24 hours and other conditions were kept constant. Further no carrier additives had been utilized but during storage, anticaking agent at the rate of 1 per cent to the prepared Noni powder.

4.2 Spray drying of Noni pulp for powder preparation

The Noni pulp was spray dried using LSD – 48 MINI SPRAY DRIER JISL. The process of spray drying of Noni pulp was standardized by monitoring various drying parameters and using food grade carriers.

4.2.1 Standardization of process for the preparation of Noni powder by Spray drying

The earlier experiments were carried out to dry the Noni pulp as such without help of any drying additives with varying inlet temperature and varying feed rate. It was observed that the powder cannot be obtained even at 180°C inlet temperature as the Noni is very sticky in nature. Hence, for further investigation maltodextrin (as binding agent) and tricalcium phosphate (as anticaking agent) were used and the protocol for the preparation of spray

dried Noni powder was standardized. The whole process for the spray drying is summarized as follows (Fig. 6).

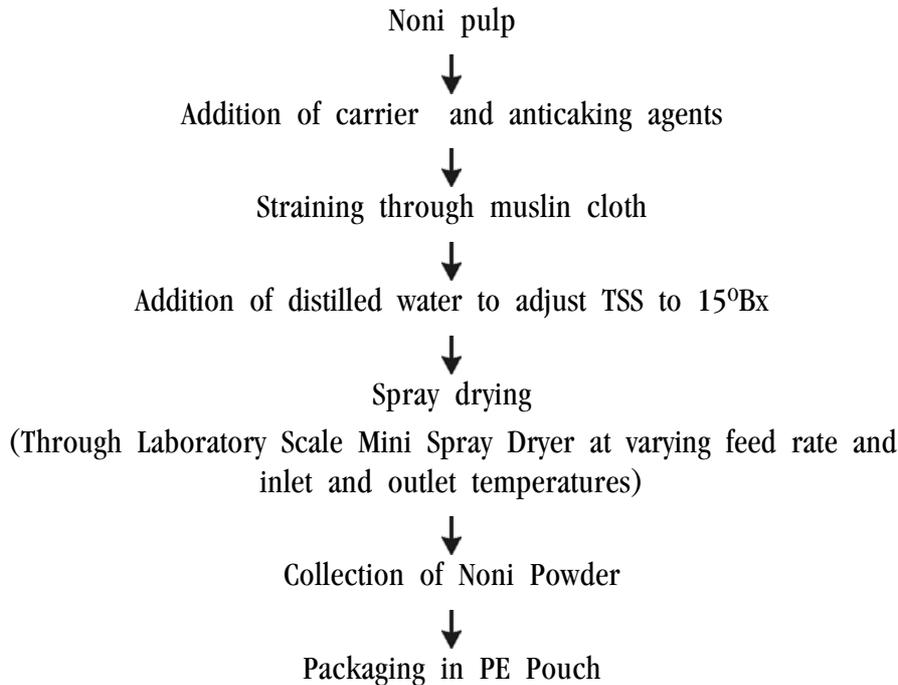


Fig. 6: Flow sheet for Preparation of Noni Powder by Spray Drying Method

4.2.2 Standardization of concentration of drying agents for Noni powder preparation

In the first initial trial of powder preparation, the prepared Noni pulp was directly fed in the spray drier. The quality of finished product obtained in first trial observed to be non satisfactory which was characterized by stickiness far from free flowing nature. The temperature as a variable factor was considered to improve the quality of the finished product but the results obtained were not up to the mark even at 180°C as an inlet temperature.

Hence, on the basis of these observations, it was observed that there is a need to use various drying agents facilitating the drying process for production

of Noni powder. On the basis of literature maltodextrin and tricalcium phosphate have been considered as externally added effective drying agents to facilitate the Noni pulp drying.

A group of experiments were designed and sub experiments in triplicate at constant feed rate (300 ml/hr), and inlet (160°C) and outlet temperature (110°C) with varying levels of maltodextrin (8, 12, 16, 20 and 24 per cent) were conducted. The tricalcium phosphate content of each sample kept constant (3 per cent).

It was interesting to note that at lower concentration of maltodextrin (i.e. 4, 8 and 12 per cent) the quality of the finished product was not up to the satisfaction.

In further investigations, it was observed that 20 and 24 per cent maltodextrin reported sticky texture and bland mouth feel. The flavour perception of Noni powder was also found non-satisfactory. It indicates that flavour profile (which may be used as an indication of heat liable nutraceutical components) of Noni powder got drastically affected. The 16 per cent level of maltodextrin certainly helped in drying the pulp in stipulated period with sustainable physical quality parameters.

Hence, 16 per cent concentration of maltodextrin in combination with 3 per cent tricalcium phosphate was underlined as an optimum concentration of additives to facilitate spray drying of Noni pulp.

On the basis of data generated from the present investigation, it was found that the Inlet temperature of 130°C with flow rate of 400 ml/hr is optimum for higher retention of some of the nutraceutical as well as good quality powder could be prepared.

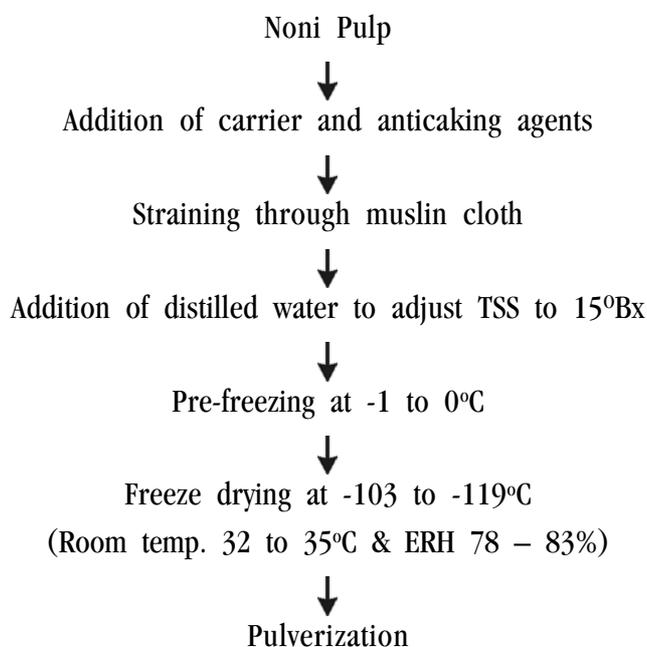
4.3 Freeze drying of Noni pulp for powder preparation

During the present investigation sincere efforts have been made to standardize the process of freeze drying for preparation of Noni powder by using laboratory scale Power Dry LL 1500 freeze dryer model. Freeze drying is achieved using equipment that controls temperature and pressure in the

surrounding of the product and is a three stage process. In principle the process is very simple, but in reality it is very complex as the product handled consists of many components, which will interact. Freeze drying is often used for sample preparation and for preservation & storage of biological and pharmaceutical materials. Freeze drying is suitable for substances that are heat sensitive. The Power Dry LL 1500 is a small, compact and easy to use freeze dryer using the wide range of accessories including a number of chambers and manifolds.

4.3.1 Standardization of process for the preparation of Noni powder by freeze drying

The earlier experiments were carried out to dry the Noni pulp as such without help of any drying agents. The quality of finished product obtained observed to be non-satisfactory like thick slurry far from free flowing nature. Hence, for further investigation maltodextrin (as carrier agent) and tricalcium phosphate (as an anticaking agent) were used and the protocol for the preparation of freeze dried Noni powder was standardized. The whole process for the freeze drying is summarized as follows (Fig. 7).



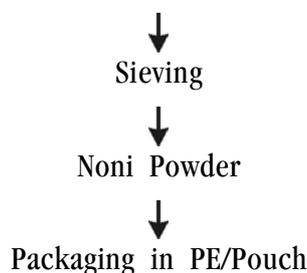


Fig. 7: Flow chart for Preparation of Noni Powder by Freeze Drying

Noni pulp initially kept as such in freeze drying jars for freeze drying at -103°C temperature of the freeze dryer and room temperature around 33°C for 4 hrs. The quality of finished product obtained observed to be non-satisfactory like thick slurry far from free flowing nature.

The room temperature, relative humidity and pre-freezing of the product are considered to improve the quality of the finished product. The ambient temperature during the course of research work lies in the range of 32 to 35°C with equilibrium relative humidity in the range of 78 to 83 per cent. Therefore, on the basis of the available theoretical information regarding freeze drying process, the Noni pulp was first pre-frozen or concentrated by keeping at -1 to 0°C in pre-freezer chamber. Even then there was no substantial improvement in powder formation and the product obtained was in the form of gritty flakes. Hence, to improve the quality of product, the efforts were made to add external drying agent and carrier before the pre-freezing of pulp. On the basis of available literature, it is found that maltodextrin and tricalcium phosphate were comparatively suitable.

In order to standardize the level of addition of maltodextrin, different levels viz. 2.5, 5.0, 7.5 and 10.0 per cent were tried and the level of anticaking agent (*i.e.* Tricalcium Phosphate) is kept constant at 1 per cent.

It was found that with increase in level of maltodextrin, the quality of powder in terms of colour and appearance improved upto the level of 5.0 per cent and thereafter, there was a significant deviation in colour and appearance of Noni powder. Hence, on the basis of above observations, it could be concluded that addition of 5 per cent maltodextrin as a carrier and 1 per

cent tricalcium phosphate as an anticaking agent in Noni pulp could be the standard as drying agents in freeze drying. Moreover, it was observed that ambient temperature of 32°C and relative humidity of 80% could assist in reaching the level of freezing temperature in the range of -103 to -119°C which gives a powder of good quality.

5. Preparation of Noni Powder Enriched Cookies

Attempts have been made to utilize Noni powder prepared by cabinet drying as a novel food ingredient for enrichment of cookies. Trials have been taken to prepare the Noni- powder enriched cookies in the Pilot Bakery Plant, College of Food Technology, Vasanttrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The production process and recipes have been standardized by conducting sensorial evaluation of different recipes and examination of physical properties of prepared cookies.

5.1 Recipe for Noni Powder enriched Cookies

5.1.1 Ingredients and Quantity

S.No.	Ingredients	Quantity
1	Refined wheat flour (g)	100
2	Sugar (g)	65
3	Fat (g)	55
4	Corn flour (g)	5.5
5	Baking powder (g)	1.5
6	Ammonia (g)	0.5
7	Noni powder (%)	@ 2, 3 & 4 per cent

The dry ingredients i.e. refined wheat flour, Noni powder, corn flour, baking powder etc. were mixed together. A homogenous paste of fat and sugar was prepared in stainless steel pan and mixed thoroughly again. The dry mix and homogenous paste of sugar and fat were mixed thoroughly.

The dough so prepared was rolled in a proper shape and thickness (6 mm) and cut into round shape cookies with the help of cutter. These cookies were baked at 175°C for 15 minutes.

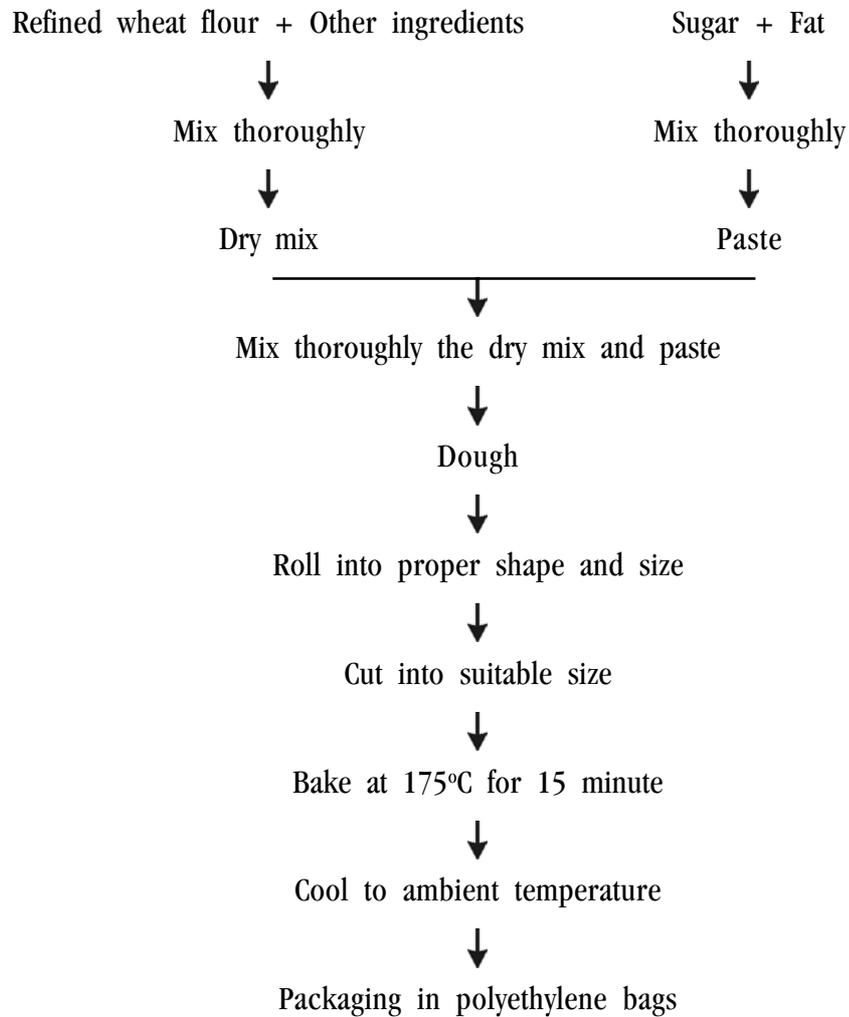


Fig. 8: Flow Chart for Preparation of Noni enriched Cookies



Fig. 9: Noni enriched cookies

5.1.2 Preparation of Noni Powder enriched Salted Biscuits or Cracker

The oven was preheated to 218°C. Refined wheat flour, sugar or other intense sweeteners/Sucralose, Rock salt, Noni powder, cumin and other dry ingredients (if any) were sifted together into a large bowl. Milk Spread and butter were cut with 2 knives until it looked like cornmeal. Milk was stirred in until the dough formed a stiff ball. On a lightly floured board, with a lightly floured rolling pin, the dough was rolled out until it was about 1/8 of an inch thick. With a 2-inch round cookie cutter dipped in flour, round crackers was cut out. These were placed on an ungreased cookie sheet or trays and pricked on the top in several places with a fork. The top of each cracker was brushed with milk. The crackers were baked for 15-20 minutes, or until they were light gold, cooled on a rack and stored airtight at room temperature in a plastic boxes.

Refined wheat flour, baking powder, sugar or intense sweeteners,
cabinet dried Noni powder and other ingredients

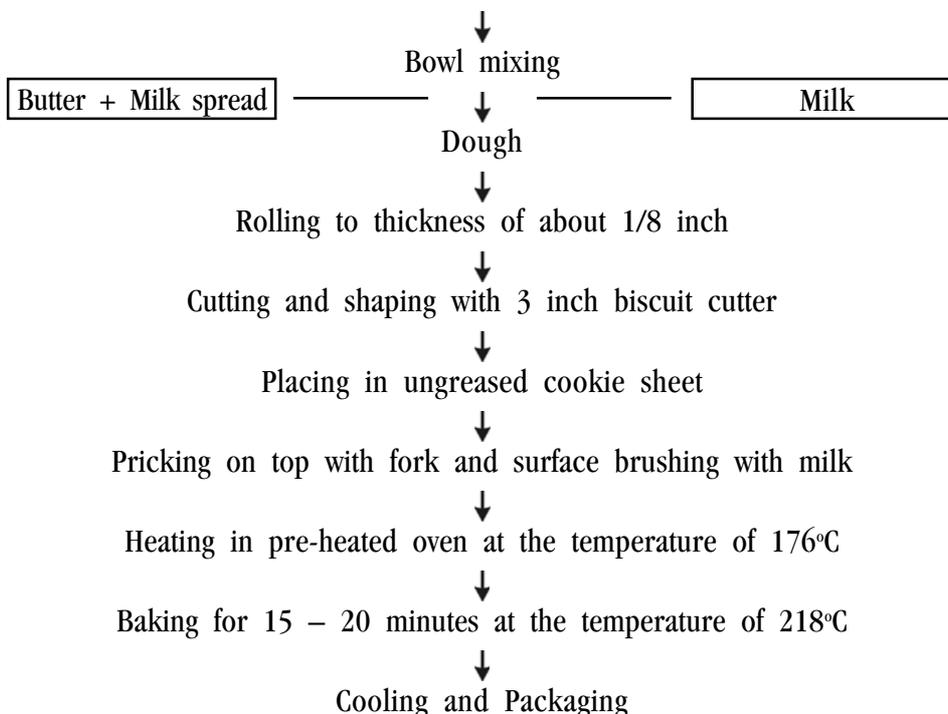


Fig. 10: Flow chart for Preparation of Noni enriched Crackers

Recipe Formulations in the preparation of Noni Enriched Crackers as follows

5.1.3. General Recipe of Crackers - Ingredients

S.No.	Ingredients	Quantity (g)	Quantity (%)
1	Refined wheat flour	112.5	100
2	Sugar	7.5	6.66
3	Butter	13.33	11.84
4	Salt	1.19	1.05
5	Baking Powder	2.0	1.77
6	GMS	2.0	1.77

The formulation requires 200ml of milk for Cracker Preparation.

Developed Recipe as per the Instructions given by Research Advisory Board using Sucralose in place of Cane Sugar and Rock Salt

S.No.	Ingredients	Quantity (g)	Quantity (%)
1	Refined wheat flour	112.5	100
2	Sugar / Sucralose	7.5/2.0	6.66/1.75
3	Milk Spread (Cholesterol Free with 70 % Fat)	13.33	11.84
4	Butter	1.3	1.15
5	Rock salt	3.0	2.66
6	Noni powder	4.5	4.0
7	Baking Powder	2.0	1.77

Trials have been carried out using water in place of milk but the quality of finished product was not up to the mark in terms of sensorial properties and palatability. Moreover it was found that moisture absorption rate was more in crackers after cooling. Further replacement of Butter with Cholesterol free Milk Spread enriched with vitamins resulted in poor texture, aroma and taste. Therefore, Butter was used in combination with Milk Spread in the ratio of 1:10. Cabinet dried Noni Powder were incorporated at the rate of

3,4 and 5 per cent and it was found that 4 percent Noni Powder incorporation level resulted in good quality crackers in comparison with others in both recipes with cane sugar and Sucralose as well.

6. Preparation of Noni based Protein Rich Powder

Since Noni with its rich nutraceutical profile could be used as major ingredient for the preparation of Protein rich powder, which will serve as Functional Foods for vulnerable groups like Children, Senior Citizens / Geriatric Persons and Women. Hence, it has been decided to formulate Noni Based Protein Rich Powder using **Soy Protein Isolate** as plant protein source.

The major reason for production of food powder form is simply to prolong the shelf-life of the ingredient by reducing water content; otherwise the ingredient will be degraded and broken down in its natural biological environment. Overall, the major function of the powder form is to maintain the stability of the ingredient functionality until it is required for utilization, which is usually in some sort of wet formulation. In addition to maintaining the stability of ingredient functionality from production right through to final powder application, other powder issues are also important in delivering the powder. These include the ability to handle and transport ingredient powders, prevention of powder contamination with undesirable organisms or chemical components, dust problems, dust fire and explosion hazards, allergy problems, creation of desirable powder particle properties, and the ability to dissolve these powders when required. Food powder handling and processing consists of a variety of operations including powder storage, transport, mixing, mixing with liquids, particle size control, particle separation, coating. It also concerns the properties of particles and powders and how this affects their bulk behaviour. An understanding of the properties and processing characteristics of these powders is an essential requirement in process design, process performance improvement and troubleshooting.

6.1. Preparation of Noni Based Protein Rich Powder using Soy Protein Isolate

6.1.1 Noni Juice Extraction

Modifications have been made in the Noni juice Extraction Technology with an intermediate step of freezing after ripening, followed by thawing. Freezing breaks the cell walls by the formation of ice crystals while Native enzymes break down pectin, hemicellulose, and cellulose during thawing making noni juice at relative low temperature, which helps in retaining phytochemicals and nutrients of original noni fruits. The freezing-juicing processing method is much more efficient than the traditional fermentation.

6.1.2 Preparation of Slurry

Mixing of Soy Protein Isolate is done with Noni Juice to make thick Slurry. Initially Soy Protein Isolate was taken in the range of 10, 20 and 30 per cent. Later on pine apple juice was blended with Noni Juice at the rate 25% to suppress foul smell of the prepared powders and slurry was made.

6.1.3 Drying

Both methods of drying i.e. Cabinet and Freeze, have been utilized for the preparation of Noni Protein Powders with different formulations/ combinations of Soy protein isolate(SPI),Noni Juice and Noni-Pineapple Juice Blends. Noni Powders were also prepared to conduct comparative studies for various Physical, Reconstitution and Morphological properties of the prepared protein powders.

7. Noni Herbal Tea

7.1 Standardization of procedure for preparation of raw materials

Shade drying at ambient temperature considered to be the generic drying method for various herbs. In case of the used herbs and spices large number of volatile, flavor imparting, bioactive components, are there and their retainability during drying is of prime importance. Hence, due care was taken to prevent loss of existing compounds and it was found that during solar drying there is considerable loss in the flavor imparting compounds and it effects the aroma characteristics of final product in remarkable manner.

The procedure followed during drying is summarized in following sheet.



Fig. 11: Flow chart for Preparation of Noni Leaf Tea

7.2 Experimental Findings

As per the objectives of the Research Project various studies/activities were carried out which are given in the following heads.

7.2.1. Physical characteristics of Noni fruit

In the present investigation, efforts have been made to study the various parameters of Noni fruit obtained from Noni orchard located at College of Food Technology, Vasantrya Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.) India.

The freshly harvested fruits were collected and examined for some physical properties. The data pertaining to important physical properties of Noni fruit are reported in Table-1.

Table 1 : Physical properties of Noni fruit

S.No.	Cultivar/Type	Physical Properties			
		Fruit (g)	Weight Seed (%)	Peel (%)	Diameter(cm)
1	Oblong				
	a. Cream	66.84	32.1	5.2	4.5
	b. Green	76.34	35.8	8.7	4.1
2	Oval				
	a. Cream	41.67	37.5	5.8	3.8
	b. Green	45.03	38.9	7.4	4.0
	Mean	57.97	36.07	6.77	4.1

* Each value is an average of ten determinations

7.2.2. Weight of fruits (g)

The weight of fruit strictly depends upon the type of cultivar used and also the other factors such as climatic conditions, soil and cultivation practices. Further, the morphology of 4 major colour based types *viz.* oblong green, oblong cream, oval green and oval cream were studied. It was observed that oblong green possesses highest weight (76.34g) while the minimum weight was observed in oval cream Noni fruit (41.67g).

7.2.3 Diameter of fruit (cm)

The diameter of fruit varies from 3.8 to 4.5 cm (Table 1). The oval green and cream varieties are at par, while oblong cream variety was found to be superior with the other varieties under study.

7.2.4 Weight of seeds (g)

The average weight of seed in the fruit varies from 32.1 to 38.9 per cent (Table 1). The oval varieties (cream and green) found to contain higher per cent of seed weight. However, the highest per cent seed weight found in oval green variety, while the oblong cream variety contains lowest per cent seed weight i.e. 32.1 per cent.

7.2.5 Weight of Peel (%)

The Peel weight of fruit varied from 5.2 to 8.7 per cent as reported in Table 1. Surprisingly, it was found that no relation with respect to oblong and oval varieties were observed, as in case of oblong cream variety, the per cent peel weight was 5.2 while in oblong green variety it was found to be 8.7 per cent.

7.2.6 Pulp content in Noni fruits

The yield of fruit pulp is one of the most important criteria for deciding the final product yield as it needs to be considered more specifically with respect to the techno-economical feasibility of the final product. The percent pulp yield was found to be highest in oblong cream cultivar (62.7 %) while the lowest yield of pulp was observed in oval green as highlighted in Table 2.

Table 2 : Pulp and juice content of Noni fruit

S.No.	Cultivar	Percent (%)	
		Pulp	Juice
1	Oblong a. Cream	62.7	50.3
	b. Green	55.5	46.4
2	Oval a. Cream	56.7	43.1
	b. Oval	53.7	40.9
Mean		57.15	45.17

* Each value is an average of three determinations

7.2.7 Juice content of Noni fruits

The juice obtained from the liquefaction of Noni pulp by pectinase enzyme was found in the range of 40.9 to 50.3 per cent as reported in Table 2. The superior juice yield was observed in case of oblong cream cultivar as compared to other cultivars.

On the basis of data on physical features of the Noni fruit of different cultivars, it could be summarized that the average weight of fruit (57.47 g), diameter (4.1 cm), per cent weight of seed (36.07), per cent weight of peel (6.77) and per cent pulp yield (57.15) were in the assessable limits and compatible for justifying processable status of fruit. On the basis of data depicted in Table 1 & 2, it was found that the oblong cream cultivar is superior with respect almost all the parameters.

7.2.8 Physico-chemical properties of Noni pulp and juice

The study was carried out to establish a preliminary data on physico-chemical parameters of Noni pulp and juice specifying their quality and the results are reported in Table-3. The Noni pulp was prepared from the ripened Noni fruits. This Noni pulp was utilized for the preparation of Noni juice by enzymatic liquefaction by pectinase enzyme.

Table 3 : Physico-chemical properties of Noni pulp and juice

S.No.	Characteristics	Noni Pulp	Noni Juice	Mean
1	Colour	10R+10.2Y+10B	10R+10.2Y+3B	—
2	TSS (%)	12.4	8.6	10.50
3	Specific Gravity	1.025	1.021	1.023
4	pH	3.5	3.6	3.55
5	Acidity (%)	1.27	1.25	1.23

* Each value is an average of three determinations

7.2.9 Colour

The colour of the pulp and juice was recorded using tintometer readings of R+Y+B. The results from Table 3 revealed that colour value varied in the

range of 10 R, 10.2 Y, 10B and 10R, 10.2Y, 3B. It was further observed that Noni juice contain clear and sparkling solution.

7.2.10 Total soluble solids (TSS)

There was a significant difference on the percent total soluble solids contents of Fruit Pulp and Juice (Table 3).The lower content of total soluble solids in juice is due to enzymatic degradation. The higher content of TSS in pulp specifies its suitability for powder preparation than juice.

7.2.11 Specific gravity, pH and acidity

The data pertaining to Acidity, pH and Specific Gravity showed that the differences were observed but are not considerable and are at par (Table 3).

7.2.12 Proximate composition of Noni pulp and juice

Proximate composition of Noni pulp and juice were studied and average values for moisture, fat, protein, carbohydrate, reducing sugar and ash are given in Table 4. The average value of above composition was found to be more in case of fruit pulp as compared to Noni juice; it may be due to more total solids in case of Noni pulp. Similar results have been reported by Chan-Blanco *et al.* (2007) for Noni pulp and Noni juice.

Table 4: Proximate composition of Noni pulp and juice

S.No.	Composition (%)	Noni Pulp	Noni Juice
1	Moisture	91.20	96.50
2	Fat	0.18	N/A
3	Protein	0.80	0.42
4	Carbohydrate	4.90	3.40
5	Reducing Sugar	2.28	1.31
6	Ash	0.40	0.20

* Each value is an average of three determinations

Vitamin C and mineral content in Noni pulp and juice

Vitamin C and mineral content in Noni pulp and juice were determined and average values of Vitamin C and minerals specially Calcium, Magnesium, Potassium and Sodium are reported in Table-5.

Table 5 : Vitamin C and mineral content of Noni pulp and juice

S.No.	Particulars (mg/100 ml)	Noni Pulp	Noni Juice
1	Ascorbic acid (Vit. C)	26.70	20.10
Minerals			
1	Calcium	39.80	10.80
2	Magnesium	21.92	18.01
4	Potassium	168.70	105.40
3	Sodium	27.00	20.00

* Each value is an average of three determinations

It is observed from the Table 5 that Ascorbic acid content was found to be 26.70 mg/100 ml in pulp as compared to 20.10 mg/100 ml in Noni juice. It may be primarily due to higher amount of total solids in case of pulp and other reasons may be effects of processing for Noni juice (Yang *et al.*, 2004).

Further from Table 5 it is observed that, the maximum value was recorded for potassium (K) i.e. 168.70 mg/100 ml in case of pulp as compared to Noni juice (105.40 mg/100 ml) .All other minerals studied viz., Ca, P, Na are having higher values in case of Noni pulp as compared to the Noni juice. It may be due to higher total solids in case of pulp than the Noni juice.

8. Development of Noni Fruit Toffee

In order to optimize the level of incorporation of Noni pulp in manufacturing of nutraceuticals toffee, different trials with varying concentration viz. 12, 14 and 16 per cent of Noni pulp incorporation were carried out. The results related to organoleptic characteristics of prepared Noni toffee are summarized in Table-6.

Table 6 : Sensory Evaluation of Noni Toffee

S.No.	Sample Code	Flavour	Body and Texture	Color and Appearance	Taste	Overall Acceptability
1	T0	8.5	9.0	8.8	8.8	8.7
2	T1	8.0	8.2	8.1	8.2	8.2
3	T2	8.0	8.2	8.0	8.2	8.2
4	T3	7.5	8.0	7.9	7.8	7.88

* Each value is an average of ten determinations

The lowest score of flavor were exhibited by a sample containing 16 per cent Noni pulp. Higher concentrations of Noni pulp were not preferred by judges due to strong fruity flavour of Noni. The highest but similar overall acceptability score exhibited by toffee prepared with 12 per cent pulp and 14 per cent pulp incorporation. While, further increase in Noni pulp concentration drastically affected the overall acceptability. It could be concluded that Toffee could be fortified up to the level of 14 per cent of Noni pulp.

It could be concluded that good quality Noni Toffee could be prepared by using 12 to 14 per cent Noni pulp. Toffees prepared by using Noni pulp with papaya or guava pulp could further enhance the sensorial quality of Noni Toffee.

9. Preparation of Noni Powder

9.1 Effect of drying methods on physical properties of Noni Powder

Effect of drying methods viz. cabinet, spray and freeze drying on some of the important physical properties of Noni powders were studied and average value of each parameter is depicted in Table 7.

Table 7 : Comparison of physical properties of Noni powder

S.No.	Drying Method	Colour	Physical properties of Noni powder				
			Appearance	Yield (%)	WSI	Bulk density(g/ml)	
						Loose	Packed
1.	Cabinet	Brown	Coarse	14.00	84.50	0.64	0.78
2.	Spray	Cream white	Fine highly hygroscopic	12.00	95.28	0.52	0.83
3.	Freeze	Beige-Brown	Fine highly hygroscopic	11.00	98.10	0.48	0.86
	Mean	—	—	—	92.62	0.546	0.823
	S.E. \pm	—	—	—	4.65	0.053	0.028
	C.D. at 5%	—	—	—	13.97	0.159	0.084

* Each value is an average of three determinations

** WSI- Water Solubility Index.

9.2 Colour

The colour of cabinet dried Noni powder was observed as a brown where as cream white & beige brown were found in case of spray dried and freeze dried respectively. The variations in the colour may be due to variations in drying conditions of respective drying methods. Similar results with respect to colour of the spray dried fruit powders were observed by Breene and Coulter (1987).

9.3 Appearance

The appearance of Noni powder was examined by visual mean and appearance was 'fine and highly hygroscopic' in both the methods i.e. spray and freeze drying where as 'coarse appearance' was recorded in cabinet dried Noni powder.

The change in the appearance from coarse to fine and hygroscopic is entirely depend upon drying conditions, process variables like carrier and anticaking additives utilization and surface area exposure of the pulp.

9.4 Water solubility index (WSI)

Water solubility index is one of the important physical properties which decides the extent of reconstitueability of food powders. In the present investigation, the effect of various drying methods on the value of WSI were recorded. The maximum WSI value was recorded in case of freeze dried Noni powder (98.1) where as the lowest value was found in cabinet dried Noni powder (84.50). The Noni powder prepared by spray drying gives 95.28 WSI value. The variation in water solubility index values among Noni powders prepared by different drying methods may be due to variations in particle size and encapsulation of carrier additives i.e. maltodextrin (Masters, 1997).

9.5 Bulk density

“Loose bulk density” measured after a powder was freely poured into a container, or “Packed bulk density” after it is allowed to compress by mechanical pressure, vibration, and impact. In particle technology, density measurement is important in separation processes (in other words, sedimentation and centrifugation) and in pneumatic and hydraulic transport of powders and particulates, or for processing condition definitions. In particular, dehydration or agglomeration processes can significantly affect the extent and nature of pore formation and hence the true particle density of the material. During mixing, transportation, storing and packaging particulate material, it is also important to know the primary properties of bulk material.

On account of the vital role of bulk density in handling, packaging, transportation and defining processing conditions, studies on loose bulk density and packed bulk density of Noni powder were carried out. Further, effect of drying methods on loose and packed bulk densities were also studied.

The average values of loose and packed bulk densities of various Noni powders were recorded in Table-8. The value pertaining to loose bulk density indicates 0.64, 0.52 and 0.48 g/100 ml for cabinet, spray and freeze dried Noni powders respectively.

The maximum packed bulk density was found to be 0.86 g/100 ml for the powder prepared by freeze drying method whereas minimum 0.78 g/100 packed bulk density was recorded in cabinet dried Noni powder.

The powder prepared by spray drying method was having 0.83g/100 ml packed bulk density. The variations in loose and packed bulk densities on Noni powders prepared by different methods may be due to drying conditions, variables of respective drying methods and addition of drying agents. Similar results were observed in case of spray drying of orange juice by Chegini and Ghobadian (2005). These results are more or less in agreements with the observations of Masters (1997).

9.6 Effect of drying methods on proximate composition of Noni powders

During the present investigation, sincere efforts have been made to study the effect of drying on proximate composition of Noni powders made by various drying methods. The proximate composition studies on moisture, protein, fat and ash content were recorded in Table-8.

Table 8 : Proximate composition of Noni powders

S.No.	Drying Methods	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
1	Cabinet	5.50	6.02	0.91	2.7
2	Spray	4.25	6.65	1.03	2.5
3	Freeze	3.76	7.30	1.22	2.9
	Mean	4.50	6.65	1.05	2.7
	S.E. \pm	0.58	0.18	0.05	0.133
	C.D. at 5%	1.75	0.53	0.14	0.4

* Each value is an average of three determinations

** The analysis is carried out by using 100 gm of powder

The per cent average values of moisture content were 5.50, 4.25 and 3.76 per cent in cabinet, spray and freeze dried Noni powders respectively. The marginal variations in protein, fat and ash content of different Noni powders were observed. Moreover, it was observed that the highest values for protein

(7.30 per cent), fat (1.22 per cent) and ash (2.9 per cent) in case of Noni powder prepared by freeze drying method. The higher values of proximate components of freeze dried Noni powder are due to lyophilization principle of this method.

10. Preparation Noni Powder Enriched Cookies

10.1 Physical properties of Noni powder enriched Cookies

Different levels of Noni powder at the rate of 2, 3 and 4 per cent have been utilized for enrichment of cookies as per recipe. The data pertaining to the physical properties of cookies is presented in Table-9. The physical properties of cookies which includes weight, diameter, thickness, spread factor and top grain occurrence have been studied. It was found from the Table-11 that 3 per cent level of Noni powder addition have shown better physical characteristics in terms of weight (22g), diameter (7.8cm), spread factor (8.21) and top grain development, followed by 4 and 2 per cent level of Noni powder addition respectively in comparison to control sample.

Table 9 : Physical properties of Cookies

S.No.	Levels of Noni Powder (%)	Weight (g)	Diameter (cm)	Thickness (cm)	Spread factor	Top grain development
1.	2	23.00	7.70	1.00	7.70	Moderate
2.	3	22.00	7.80	0.95	8.21	Most
3.	4	24.00	7.70	1.00	7.70	Most
4.	0 (Control)	22.50	6.70	1.15	5.82	Rare
	Mean	22.87	7.47	1.02	7.33	—

* Each value is an average of Ten determinations

Therefore, it can be concluded from the above values that there is a significant impact of Noni powder addition on physical properties of cookies which could enhance the market value of cookies and 3 per cent level addition can be considered to be the optimum level.

10.2 Effect of different levels of Noni powder on organoleptic properties of Cookies

During present investigation, four samples of cookies were prepared viz. one control without Noni powder and three samples with 2, 3 and 4 per cent of Noni powder. All four samples were compared for the sensorial quality.

Samples code:

A – 2 per cent Noni powder

B – 3 per cent Noni powder

C – 4 per cent Noni powder

D – control without Noni powder

10.3 Organoleptic Quality of Noni Powder Enriched Cookies

The panel of semi trained judges consisting of 10 members was given the cookies samples for evaluation of organoleptic characteristics viz. appearance, colour, taste, flavour, texture and overall acceptability. It was served to judges on the day of preparation. By summing up the scores obtained for all these characteristics, the overall acceptability scores were obtained. Thus, the average score recorded by judges was considered and means of 4 replications were presented in Table-10.

Table10 : Average sensory score of Noni powder enriched Cookies

S.No.	Sample Code	Appearance	Colour	Taste	Flavor	Text-ure	Overall Acceptability
1	A	7.6	7.6	8.0	7.6	8.8	7.6
2	B	7.0	7.0	7.3	7.0	7.3	7.1
3	C	7.4	7.0	7.7	7.5	7.3	7.5
4	D	7.7	8.0	8.0	7.7	7.9	7.9
5	Mean	7.42	7.40	7.76	7.46	7.82	7.52
	SE \pm	0.07	0.15	0.08	0.07	0.26	0.11
	C.D. at 5%	0.21	0.45	0.25	0.20	0.77	0.33

* Each value is an average of ten determinations

10.4 Appearance

From the results presented in Table-12, it is revealed that control sample (D) received top score of 7.7 for appearance. It was followed by sample A valued at 7.6. Sample C with highest level of Noni powder (i.e. 4 per cent) was above the minimum acceptable level of 6.

From the Table-12, it is observed that Noni powder had no significant effect on the appearance of cookies. Results showed that sample A with 2 per cent Noni powder was at par with the control, valued at 7.6 in case of appearance of cookies sample.

10.5 Colour

It may be visualized from Table-12, that Noni powder combination exhibited not much differences with regard to colour character of final product ranging from 7.0 to 8.0. Control scored highest at 8.0 followed by samples A (7.6) and both were rated between like moderately to like very much. It was interesting to note that samples B and C with combination of 3 and 4 per cent Noni powder were at par with score of 7.0 for colour characteristic of cookies.

10.6 Taste

The best taste was observed in case of sample A at par with control. Followed by samples C, whereas, sample B scored less i.e. 7.3 in comparison to control and other samples. It is important to note from the present findings the taste characters were decisively governed by the level of Noni powder and also there was an after taste feels as reported by judges depending on level of powder addition. The taste may be taken as a sum total of combination of refined wheat flour, ghee, sugar, corn flour and inherent taste and flavour characters of Noni powder. Hence, the taste of 2 per cent Noni powder addition in cookies might not affect the generic taste of cookies.

10.7 Flavour

The result presented in Table-12 indicates that the flavour character was also dominated by sample A (7.6) at par with control (7.7) as in case of

appearance and colour characteristics. Further, sample C was again very near to sample A which valued at 7.5 score and sample B is having lowest with 7.0 score. Here also judges reported after taste feel of generic Noni flavour which is due to scopoletin component of Noni.

10.8 Texture

It can be observed from the Table-12 that Noni powder combinations exhibited wide differences with regard to texture character of final product ranging from 7.3 to 8.8.

Sample A scored highest at 8.8 followed by control (7.9) and both rated in between like very much to like extremely. It was interesting to note that the both sample B and C scored same i.e. 7.3. It was observed that Noni powder had significant effect on the texture of cookies but its effect is desirable at the level of 2 per cent Noni powder addition and an increase in Noni powder addition affects reversibly on texture of cookies.

10.9 Overall acceptability

It is seen from the results that variation do exists in overall acceptability score. All the combinations of Noni powder addition valued in between like moderately to like very much. Lowest score was observed in sample B. The overall acceptability of cookies could be attributed to the different characters of appearance, colour, taste, flavour and texture of the final product. It is revealed from the scores of the overall acceptability that the Noni powder can be successfully incorporated between 2 to 3 per cent as a nutraceutical in cookies.

10.10 Sucralose incorporation in cookies

Efforts were also made to judge the suitability of sucralose (artificial sweetener) for cookies preparation in replacement of cane sugar (Sucrose). Cane Sugar was replaced with equivalent quantity of Sucralose in terms of sweetness by volume by using following recipe (Table-11).

Table 11 : Sugar-free Recipe for Noni Powder enriched Cookies

S.No.	Ingredients	Quantity
1	Refined wheat flour (g)	100
2	Sucralose (g)	6.5
3	Fat (g)	55
4	Corn flour (g)	5.5
5	Baking powder (g)	1.5
6	Ammonia (g)	0.5
7	Noni powder (g)	@ 2, 3 & 4 per cent

It was found that prepared cookies were found to be very hard in texture which was against the desirable crispy and crunchiness attributes. It was found that cane sugar is responsible for desirable texture in cookies as a generic ingredient. Hence, the idea of replacing sugar with artificial sweeteners in preparation of cookies has been dropped.

11. Noni Powder enriched Salted Biscuits or Crackers

Trials have been carried out using water in place of milk but the quality of finished product was not up to the mark in terms of sensorial properties and palatability. Moreover it was found that moisture absorption rate was more in crackers after cooling. Further replacement of Butter with Cholesterol free Milk Spread enriched with vitamins resulted in poor texture, aroma and taste. Therefore, Butter was used in combination with Milk Spread in the ratio of 1:10. Cabinet dried Noni Powder were incorporated at the rate of 3,4 and 5 per cent and it was found that 4 percent Noni Powder incorporation level resulted in good quality crackers in comparison with others in both recipes with cane sugar and Sucralose as well.

Table 12 : Sensory scores for various samples of Noni Crackers

S.No.	Sample Code	Color	Appearance	Aroma	Taste	Texture	Mouth Feel	Overall Acceptability
1	Control	8.0	8.0	8.0	8.0	8.0	8.0	8.00
2	A	8.0	8.0	8.0	7.0	8.0	7.0	7.60
3	B	8.0	7.5	8.0	7.0	7.5	7.5	7.58
4	C	8.0	7.5	7.0	7.0	7.0	7.5	7.30
5	D	7.9	7.5	7.5	6.8	7.7	7.0	7.4

* Each value is an average of 10 determinations

A = Noni + butter + milk + milk spread + rock salt

B = Noni + water + butter

C = Noni + butter + milk spread + water

D = Noni + butter + milk spread + water + Sucralose

The aim was to utilize cabinet dried Noni powder in combination with selected health friendly ingredients viz. milk spread (cholesterol free with 0 per cent fat) sucralose and rock salt as a substitute for generic ingredients like butter, sugar and salt respectively.

On the basis of obtained results, it could be concluded that an acceptable quality crackers can be prepared by using 4 per cent Noni powder, 1.75 per cent sucralose and 11.84 per cent milk spread.

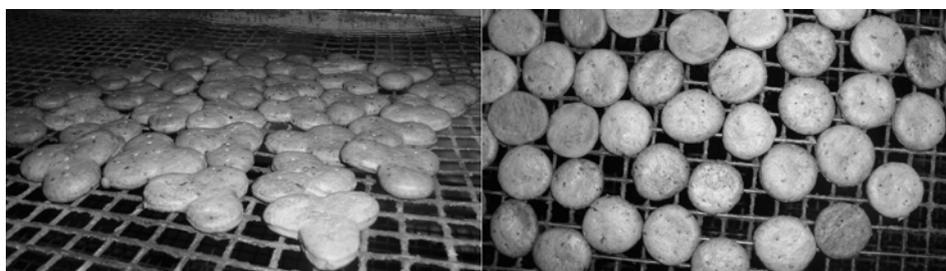


Fig. 12: Noni Crackers

12. Preparation of Noni Based Protein Rich Powder

Findings of the various studies are presented in a Tabular and Graphical forms.

Table 13 : Physical Properties of Noni fortified Powders

S. No.	Sample Code	Moisture (%)	Particle size (µm)	Particle Density	True Density	Bulk Density	Tapped Density	Porosity Hydration Capacity	Water
1	SPI FD-10	0.20	75.05	2.5	1.22	0.499	0.72	5.9	2.6
2	SPI FD -20	0.20	83.21	5	1.94	0.575	0.683	7.03	2.9
3	SPI FD- 30	0.25	90.87	5	1.38	0.626	0.846	5.46	3.44
4	PBN (20 SPI-CD)	2.7	90.8	10	1.58	0.546	1.321	6.54	1.9
5	PBN (25 SPI-CD)	2.9	116.62	3.33	1.42	0.535	0.658	6.25	1.24
6	Noni Powder-CD	4.5	149.75	5	1.33	0.648	0.934	5.12	5.62
7	Noni Powder-FD	2.2	117.2	10	1.42	0.531	0.71	6.26	6.92

SPI FD-10: Noni Protein Powder prepared by Freeze Drying using 10% Soy protein isolate(SPI) and 90% Noni juice

SPI FD-20: Noni Protein Powder prepared by Freeze Drying using 20% SPI and 80% Noni juice

SPI FD-30: Noni Protein Powder prepared by Freeze Drying using 30% SPI and 70% Noni juice

PBN (20 SPI-CD): Noni Protein Powder prepared by Cabinet Drying using 20% SPI and 80% Pineapple- Noni Blend juice

PBN (25 SPI-CD): Noni Protein Powder prepared by Cabinet Drying using 25% SPI and 75% Pineapple- Noni Blend juice

Noni Powder-CD: Noni Powder prepared by Cabinet Drying

Noni Powder-FD: Noni Powder prepared by Freeze Drying

Fig. 13: Different methods used for Noni Powder preparation

Reference Tables for Powder Flowability and Cohesiveness

Table 14 : Classification of powder Flow ability based on Carr index (CI-1965)

S. No.	Carr Index (%)	Flow ability
1	<15	Very good
2	15–20	Good
3	20–35	Fair
4	35–45	Bad
5	>45	Very bad

Table 15 : Classification of Powder Cohesiveness based on Hausner ratio (HR – 1967)

Sr. No.	Hausner Ratio (%)	Cohesiveness
1	<1.2	Low
2	1.2–1.4	Intermediate
3	>1.4	High

Based on the above mentioned studies it was found that the Noni Protein Powder prepared by cabinet drying using 25% Soy Protein Isolate and Noni-Pineapple Juice Blend was superior in terms of Physical, Reconstitution and Morphological properties in comparison with other powder samples. Moreover PBN (25 SPI-CD) Noni Protein Powder sample was found highly acceptable for its sensorial properties.

13. Noni Leaf based Herbal Tea

Herbal Teas are one of the oldest and most comforting of herbal remedies. Herbal tea remedies utilize a limitless combinations of ingredients, and are popular for a variety of conditions and detoxes. Herbal tea usually contains one or many herbal ingredients, which have several therapeutic functions. Also benefits obtained from herbal tea depend upon the herbs used for its preparation. Usually, it can be referred that, herbal tea helps in relaxation,

promotes cardiovascular health, strengthen the immune system, rids the body of toxins, support absorption of natural fluids. It also acts as an antioxidant and energy booster. It is effective for losing weight as well as getting a good night's sleep, etc.

Noni (*M. citrifolia* L.) is a tree in the family Rubiaceae. Parts of the plant have been traditionally used for treatment of various complaints or diseases. The leaves were investigated and reported to have several polyphenolic compounds, including ursolic acid, quercetin, kaempferol and rutin. An ethanolic extract of Noni leaves posses wound healing activity (Shivananda *et al.*, 2007) and has been shown to be safe in acute, sub-acute and sub-chronic oral toxicity tests on mice (West *et al.*, 2007). Rutin has been reported to have antioxidant, anti-diabetic, anti-inflammatory and anticancer activity (Marzouk *et al.*, 2007).

Standardization of these remedies is needed to obtain a product with higher nutraceutical value, for this herbal authenticity, purity and assays are important aspects of the standardization and quality control. Hence, the efforts have been made to carry out studies on development and standardization of herbal tea using dried Noni leaves powder in combination with spices/herbs and medicinal plants which includes cinnamon, coriander, cumin, cardamom, ginger and citric acid.

Table 16 : Sensory scores for Noni Leaf Herbal Tea

S.No.	Sample Code	Appearance	Colour	Flavour	Taste	Overall Acceptability
1	A	8.0	8.0	7.0	7.0	7.0
2	B	6.0	5.0	5.0	5.0	6.0
3	C	6.5	6.5	8.0	8.0	7.0
4	D	7.0	8.0	8.0	8.0	8.5

* Each observation is an average of ten determinations

Four samples of Noni Leaf Herbal Tea were prepared and subjected to sensorial evaluation. It was observed that sample B containing only Noni leaf

powder showed dull appearance and colour, flavor and taste properties. Sample C contained various spices and herbs showed increased score for flavor, taste and overall acceptability, where as sample D exhibited highest sensory score with respect to colour, flavor, taste and overall acceptability among all investigated samples.

Caffeine free tea can be made from nutrient rich Noni leaves. The sensory properties like taste, aroma, flavor and therapeutic properties can be enhanced/improved by fortifying herbs, spices, medicinal and aromatic plant parts.

It has been reported that Noni fortified herbal leaf tea is caffeine free and could help in eliminating toxins from body maintaining proper digestion and healthy immune system, protecting cells from free radical damage, reducing stress, cleansing body and help with mental acuity and concentration.

The investigation on was carried out to develop and standardize Noni leaves based blend of herbal tea with higher antioxidant potential. Other ingredients were selected depending upon their therapeutic value, were used in the development of herbal tea. The process of drying of ingredients was standardized so as to reduce the loss of flavor imparting compounds and also the antioxidant potential. The prepared powders were utilized in formulation of recipe of herbal premix; the recipe was standardized by using trial and error method.

5. Summary and Conclusion

Noni (*Morinda citrifolia* L.) being a super fruit containing more than 160 nutraceuticals was selected as the base agro material for its exploitation as a cheapest source for formulation of innovative and low cost functional foods/health foods in this research project. As per the objectives of the research project sincere attempts were made to analyze the properties of Noni fruit, juice and pulp and utilized them in preparation of value added products.

It was found that mean yield of pulp was ranges from 53.7 to 56.7 per cent (Oval type) and 55.5 to 62.7 per cent (Oblong type). The juice content was

in the range of 40.9 to 43.1 per cent for Oval and 46.4 to 50.3 per cent for Oblong cultivar. Noni juice was found to be acidic in nature with the range of 3.5 to 3.6 pH. Chemical compositional profile revealed that Noni juice contained 96.50 per cent moisture while pulp contained 91.20 per cent moisture. Noni contained appreciable amount of vitamin C and minerals like calcium, magnesium, potassium and sodium.

In research investigation pertaining to value added product development using Noni pulp. It was found that Noni fruit toffee could be successfully prepared using Noni pulp in the range 12 to 14 per cent.

Technology for Noni powder preparation was investigated using different methods *viz.* cabinet drying, spray drying and freeze drying. Among the used drying methods, it was observed that freeze drying found optimum in terms of its density and water solubility index while cabinet drying of Noni pulp into powder resulted in highest yield. The chemical composition of Noni powder remained more or less similar in all investigated samples. On the basis of cost efficiency cabinet dried Noni powder was selected for further investigation.

Moreover, Cabinet dried Noni powder was used for preparation of Noni enriched cookies. It is revealed from the sensorial evaluation that Noni powder can be successfully incorporated between 2 to 3 per cent as a nutraceuticals in cookies. While replacing sugar with sweetener (sucralose), it was found that sucralose resulted in hard texture and hence idea of further investigation on use of artificial sweeteners in cookies was dropped.

With the success for Noni powder in cookies preparation, Noni powder was further tried in preparation of salted crackers. Cabinet dried Noni powder was incorporated at the rate of 3, 4 and 5 per cent and it was found that 4 per cent Noni powder incorporation level resulted in good quality crackers.

Further, efforts were made to incorporate Noni powder in combination with Soy Protein Isolate for preparation of Noni based Protein Rich Powder to serve as functional food for vulnerable groups. Based on results it was found that Noni Protein Powder prepared by cabinet drying using 25 per

cent Soy Protein Isolate and Noni-Pineapple Juice blend was superior in terms of physical, reconstitution and morphological properties in comparison with other samples.

In order to utilize Noni leaf as herbal ingredients for preparation of Noni Leaf Tea, the process of drying of ingredients was standardized so as to reduce the loss of flavor imparting compounds and also to maintain antioxidant potential. The prepared powders were utilized in formulation of recipe of herbal premix; the recipe was standardized by using trials and error methods. It was found that Noni Leaf Tea with better sensorial quality profile could be successfully prepared using 50 per cent Noni leaf powder, 15 per cent ginger powder, 12.5 per cent coriander, 12.5 per cent cumin seeds, 5 per cent cardamom and 5 per cent citric acid.

Further, it could be concluded that in this research investigation for all the value added products from Noni needs scaling up of developed process on pilot scale for commercial exploitation.

References

- Breene, W.M. and Coulter, S.T. 1987. Properties of spray dried combinations of milk and fruits and vegetables. *Journal of Food Science and Technology*. 13(5):195-201.
- Chan-Blanco, Y., Vaillant, E., Pérez, A.M., Belleville, M.P., Zuniga, C. and Brat, P. 2007. The ripening and aging of noni fruits (*Morinda citrifolia* L.). Microbiological flora and antioxidant compounds. *Journal of Science of Food and Agriculture*, 87(9):1710-1716.
- Chandra, V. 2010. Development of processed products from Noni (*Morinda citrifolia* L.) WNRF Technical Bulletin 07, World Noni Research Foundation and Queen Mary's college (Autonomous), Chennai, India.
- Chegini, G.R. and Ghobadian, B. 2005. Effect of Spray-Drying Conditions on Physical Properties of Orange Juice Powder. *Drying Technology*, 23(3): 657-668.

- Kulkarni, D.N., Satwadhar, P.N. Deshpande H.W., Siddiqui A.N. and Tondgaonkar S.B. 2007. *Noni: A gift of nature In: Agrobased Nutraceuticals. College of Food Technology, Marathwada Agricultural University, Parbhani Publication.* pp: 58-108.
- Marzouk, M.S., Soliman, F.M., Shehata, I.A., Rabee, M. and Fawzy, G.A. 2007. Flavonoids and biological activities of *Jussiaea repens*. *Natural Product Research*, 21(5):436-43.
- Masters 1997. Drying of droplets/sprays. In Spray drying handbook. New York; Halsted Press pp: 291-335.
- Shivananda, N.B., Steve, S. and Maxwell, A. 2007. Evaluation of the wound-healing activity of Ethanolic Extract of *Morinda citrifolia* L. Leaf. *Evidence Based Complement Alternate Medicine*. 6(3): 351–356.
- West, B.J., Tani, H., Palu, A.K., Tolson, C.B. and Jensen, C.J. 2007. Safety tests and antinutrient analyses of noni (*Morinda citrifolia* L.) leaf. *Journal of Science of Food and Agriculture*, 87(14):2583-8.
- Yang, J., Paulino, R.J., Janke-Stedronsky, S. 2004. Total Antioxidant Capacity of Noni (*Morinda citrifolia* L.) Products as Affected by Processing and Storage. The Worldnutra, 2004 Conference. Poster Session #30.