DEVELOPMENT AND POPULARISATION OF VALUE ADDED FOOD PRODUTS USING LOTUS ROOT (Nelumbo nucifera)

DISSERTATION SUBMITTED

In Partial Fulfillment of the Requirement for the Award of the Degree of

MASTER'S PROGRAMME IN

CLINICAL NUTRITION AND DIETETICS

BY

MARIA SAJU

(Register No: SM19MCN008)

DEPARTMENT OF CLINICAL NUTRITION AND DIETETICS

ST. TERESA'S COLLEGE (AUTONOMOUS)

ERNAKULAM

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CERTIFIED AS BONAFIDE RESERCH WORK

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Signature of the
the External Examiner

Signature of
Internal Examiner

DECLARATION

I hereby declare that the thesis entitled "**DEVELOPMENT AND POPULARISATION OF VALUE ADDED FOOD PRODUCTS LOTUS ROOT (Nelumbo nucifera)**" submitted in partial fulfillment of the requirement for the award of the Degree of Master's Programme in Clinical Nutrition and Dietetics is a record of original research work done by me under the supervision and guidance of Dr. Priya Pillai, Assistant Professor, Department of Clinical Nutrition and Dietetics , Women's Study Centre, St. Teresa's College(Autonomous), Ernakulam and that the thesis has not previously formed on the basis for the award of any degree work has not been submitted in part or full or any other degree/diploma/ fellowship or the similar titles to any candidate of any other University.

Place: Maria Saju

CERTIFICATE

I hereby certify that the dissertation entitled "**DEVELOPMENT AND POPULARISATION OF VALUE ADDED FOOD PRODUCT USING LOTUS ROOT (Nelumbo nucifera)**" submitted in partial fulfillment of the requirement for the award of the **Degree of Master's Programme in Clinical Nutrition and Dietetics** is a record of original research work done by Ms. Maria Saju during the period of her study under my guidance and supervision.

Signature of the HOD

Signature of the Research Guide

Dr. Priya Pillai

Assistant Professor

Department of Clinical Nutrition and

Women's Study Centre

St. Teresa's College, Ernakulam

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MARIA SAJU

ABSTRACT

ABSTRACT

The present study entitled “Development and popularization of value added food product using lotus root (Nelumbo nucifera)” was done with an aim to prepare lotus root powder incorporated food products, to study their shelf life qualities and to popularize these products among the adolescent girls. The study also measured awareness of the adolescent girls about lotus root powder. In order to meet the objectives, four product were prepared by incorporating Lotus root namely, Lotus root cake, Lotus root cookies, Lotus root nutria bar and Lotus root health mix. These food products are mainly made in three variations namely variation A, variation B and variation C in which they are incorporated by lotus root in 20 percent, 30 percent and 50 percent along with the other ingredients to enhance the quality and quantity of the nutrients in the developed products. The Lotus roots have been in the powdered form by using different methods to dry to obtain best quality in the powdered form.

A score card was prepared for the selected judging panel of twenty four members. A nine point score card was prepared to evaluate the sensory qualities of the developed and prepared products. Organoleptic evaluations of the sensory qualities of the prepared products were done by the hedonic scale. Among the prepared variations, those variations with highest overall acceptability score were considered as the best variation of the product. By testing the framed hypothesis using Friedman’s ANOVA test, the alternate hypothesis for the test was identified. It was revealed that sample do not differ from each other in their overall acceptability. So the null hypothesis was rejected.

The nutrient content of the best variation of each Lotus root incorporated product per 100g was assessed with reference to their calcium, iron and dietary fiber content. Lotus root incorporated products were found to be rich in nutrients especially calcium, iron, while it also supplied with adequate amount of calories, carbohydrate and fat. The developed products were analyzed for their self-life qualities for a period of 3 months at room temperature. The best variation of each Lotus root incorporated products were also evaluated for the time taken in preparing them. Among the developed products, two of the products with highest overall acceptability scores namely Lotus root cookies (8.04) and Lotus root nutria bar (8.41).

For the process of popularization, a questionnaire which collected information about the awareness of Lotus root, a brochure which explained the nutritional and medicinal benefits of Lotus root, a score card for the sensory evaluation of Lotus root incorporated products and a questionnaire which collected the feedback from the adolescent girls were prepared and presented. Each product were then organoleptically scored by the judging panel. The responses given by the adolescent girls showed that they had the interest to cultivate and also to incorporate Lotus root in their daily diet**.**

The process of drying method mainly used are sun drying, oven drying and pan drying. Each methods gives different texture and color by using the drying methods adapted. Among the various methods of drying used the best way was sun drying where the taste, color and flavor is being maintained.

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CHAPTER 1

INTRODUCTION

"Adolescence" is a dynamically evolving theoretical construct informed through physiologic, psychosocial, temporal and cultural lenses. This critical developmental period is conventionally understood as the years between the onset of puberty and the establishment of social independence (Steinberg, 2014). The most commonly used chronologic definition of adolescence includes the ages of 10-18, but may incorporate a span of 9 to 26 years depending on the source (Curtis, A. C. 2015).

"The term "adolescence" is derived from the Latin word "AD- OLESCERE" meaning "TO GROW" or "TO MATURE". Adolescence is one window of opportunity which can be used effectively to inculcate good practices in individuals and hence in community. World Health Organization has defined 'adolescence' as a period between 10 and 19 years. Adolescence in girls has been recognized a special period of transition from girlhood to womanhood. Adolescent girls constitute one fifth of the female population in the world. Adolescence is a transitional period between childhood and adulthood. The world is home to 1.2 billion individuals aged 10–19 years. 240 million (20%) of the world's adolescents live in India and 115 million (48%) of Indian adolescents are girls. There is global consensus that investing in adolescents, particularly girls, can accelerate the fight against deprivation, inequity and gender discrimination" (Abirami, M, 2020)

According to World Health Organization (WHO). (2018) explains about adolescence, independence and autonomy from family increases and peer relations become more significant. At the same time, family and parents or caregivers have a great impact on adolescent health. On one hand, family connectedness protects from multiple health risks. On the other, family circumstances can also cause harm, including through violence and abuse, impairment of identity development (e.g. attitudes towards gender and sexual identity), harmful practices (e.g. child marriage, female genital mutilation/cutting), or parental absence and migration. Families can also act as a powerful gatekeeper for access to education, health services, and other resources. The social, emotional and physical environments in which adolescents live and learn have significant influence on their health. From climate change to armed conflict, migration and economic downturns, adolescents are also – and sometimes disproportionally – affected by the risks and opportunities stemming from urbanization and globalization.

According to Dambal, S., et.al (2018) explained that adolescent group can be targeted to address the issue of nutritional correction to reduce the long term impacts of Anemia. Adolescent girls are the most neglected & vulnerable in terms of nutrition, health education, and overall growth and development is concerned. In India, it is estimated that about 56% of the Adolescent girls are prone to Anemia, which means at any given point of time about 6.40 Crore adolescent girls are suffering from Anemia.

According to Hruby, A., et.al (2015) explained about obesity is typically defined quite simply as excess body weight for height, but this simple definition belies an etiologically complex phenotype

primarily associated with excess adiposity, or body fatness, that can manifest metabolically and not just in terms of body size. Obesity greatly increases risk of chronic disease morbidity—namely disability, depression, type 2 diabetes, cardiovascular disease, certain cancers—and mortality. Childhood obesity results in the same conditions, with premature onset, or with greater likelihood in adulthood

According to Raj, M., et.al (2010) explained about obesity is an independent risk factor for CVD. Obesity is associated with an increased risk of morbidity and mortality as well as reduced life expectancy. The last two decades of the previous century have witnessed dramatic increase in health care costs due to obesity and related issues among children and adolescents.

According to Rose-Clarke, K., et. al (2019) explains that India has the largest cohort of adolescents in the world, approximately 243 million. A recent national review found that adolescents were commonly affected by both under and over nutrition, common mental disorders, substance use and violence. Girls are particularly vulnerable: 45% of girls aged 15–18 have a BMI less than 18.5, and 27% of women aged 20–24 were married before the age of 18. Sixty-eight percent of women are literate compared to 86% of men. These national figures mask important inequities across States, and between wealth and caste/tribal groups. Scheduled Tribe, or adivasi (i.e. indigenous) communities constitute 9% of India's population - over 104 million people. Although concentrated in Central, Eastern and North East India, such communities exist across India.

According to Lin, Z; et al, (2019) explained that lotus is a perennial aquatic plant. It belongs to the small family of *Nelumbonaceae*, comprising of only one genus Nelumbo with two species: *Nelumbo nucifera* Gaertn. And Nelumbo *lutea* Pear which are popularly named as Asian lotus and American lotus, respectively. Generally, lotus refers to Asian lotus and mainly distributes in Asia and the north of Oceania, while the American lotus primarily occurs in the eastern and southern parts of North America, as well as the north of South America. Asian lotus is also named as sacred lotus because of its significance in the religions of Buddhism and Hinduism. It is a very good symbol in Chinese traditional culture. All of these make sacred lotus a very popular ornamental plant.

Lin, Z; et al, (2019) also explained, it is also a popular vegetable and traditional medicinal plant with great economic value in South-East Asia. China is regarded as one of the major centers in lotus cultivation and breeding, with over several thousands of years of cultivation history. As the result of the long period of breeding, domestication and cultivation, large amounts of lotus cultivars have been obtained, showing variable morphology and other traits. The cultivated lotus is generally divided into three categories, namely, rhizome, seed and flower lotus, according to their usage in reality.

Lin, Z; et al, (2019) also explained that the lotus rhizome and seed could not only be consumed as vegetables, but are also used for lotus propagation, whereas, the flower lotus is mainly applied in ornamentation and environmental improvement. Based on the climatic regions they are accustomed to, sacred lotus could also be classified into two ecotypes, which are temperate lotus

and tropical lotus. The temperate lotus has an enlarged rhizome occurring after flowering and its leaves wither. In contrast, the tropical lotus has a whip-like rhizome with a longer green period and flowering time.

According to Guo, H. B. (2009) explained about the lotus plant *Nelumbo* (Nelumbonaceae), an aquatic perennial herb, with a disjunctive Lotus (*Nelumbo nucifera* Gaertn. ssp. *nucifera*), one of 12 aquatic species used as vegetable, has been cultivated for more than 2,000 years, and now has been widely cultivated in almost all provinces in China. The largest area under cultivation of lotus is located in the regions surrounding mid-down Yangtse River, including Hubei, Jiangsu, Zhejiang, Anhui, Jiangxi and Hunan provinces. According to different purposes or morphological differences, the Chinese lotus (*N*. *nucifera* ssp. *nucifera*) is usually classified into three types: rhizome lotus, seed lotus and flower lotus.

Rhizome lotus is mainly cultivated in Hubei, Jiangsu, Anhui and Zhejiang provinces; Seed lotus in Jiangxi, Fujian and Hunan, and flower lotus in Wuhan, Hubei province, and Beijing. Up to the year 2002, a total of 572 lotus accessions (including landraces, cultivars and breeding lines) were conserved in National Garden of Aquatic Vegetable, Wuhan, Hubei province, including those collections from 153 counties in 18 provinces, and lines bred by breeders. Out of these accessions, 310 were rhizome lotus which contains 201 landraces and 109 breeding lines; 229 were flower lotus including 172 cultivars and 57 breeding lines; and the rest 33 were seed lotus with 18 cultivars. (Guo, H. B. 2009).

According to Ming, R.,et al. (2013) explained about the sacred lotus, so named because of its religious significance in both Buddhism and Hinduism, belongs to the small plant family Nelumbonaceae, with only one genus, *Nelumbo*, and two species: *N. nucifera* (Asia, Australia, Russia) and *N. lutea* (eastern and southern North America). Lotus is in the eudicot order Proteales, which lies outside of the core eudicots; its closest relatives are shrubs or trees belonging to the families Proteaceae and Platanaceae. Lotus was a land plant that has adapted to aquatic environments.

Ming, R., et al (2013) explained about the use as a food for over 7,000 years in Asia, lotus is cultivated for its edible rhizomes, seeds and leaves. Its buds, flowers, anthers, stamens, fruits, leaves, stalks, rhizomes and roots have been used as herbal medicines for treatment of cancer, depression, diarrhea, heart problems, hypertension and insomnia. Its seeds have exceptional longevity, remaining viable for as long as 1,300 years, and its vegetative rhizomes remain healthy for more than 50 years. The nanoscopic closely packed protuberances of its self-cleaning leaf surface have been adapted in Europe for the manufacture of a 'self-cleaning' industrial paint, Lotusan. The use of this paint results in the so-called lotus effect that is now widely advertised for self-cleaning automobiles, buildings and fabrics.

According to Yi, Y.et al (2016) has explained that lotus has been widely cultivated for food production, ornamental horticulture and traditional Asian medicine in China, Korea, Japan and India. Its root, which contains abundant dietary fibers, starches, sugars, proteins, amino acids,

minerals, vitamins and phenolics is popularly consumed as both a delicious and nutritional vegetable and a therapeutic herb. Some pharmacological potentials of the ethanol- and methanol-soluble extracts of lotus root, including antioxidant, immunomodulatory, antiobesity, hypoglycemic, psychopharmacological and memory-improving activities, are proposed to be closely related to phenolic compounds. Lotus is found throughout India. It is widely found in the Bandhavgarh National Park, Eravikulam National Park in India. North of Kuttippuram offers beautiful sights of lotus cultivation on either side of the railway tracks. Lotus is cultivated on more than 20 acres in Thirunavaya and the village holds the distinction of the largest lotus farming done in a single spot in the State.

According to Mandal, R. N. el at (2013) explained that the lotus is very much a part of Indian cultural traditions. Its importance has long been recognized and it has been grown for use as food, medicine and also for cultural and religious activities. Significantly, the longevity of the lotus seed is phenomenal, with viable seeds dated as being 1300 years old. Seed germination of the lotus is very rare in Nature; however, farmers' knowledge and experience may show how lotus seeds can be germinated.

According to Mukherjee, et al. (2009) explained that the rhizomes are 60–140cm long, 0.5–2.5 cm in diameter, yellowish white to yellowish brown, smooth, with longitudinal striations and brown patches, and with nodes and internodes. Transverse section of the rhizome shows an outer layer of epidermis, surrounded by cuticle followed by a dense sub-epidermal layer, a spongy layer and an inner dense layer, continuous with the parenchyma cells. When freshly cut, the rhizome

exudes mucilaginous juice and shows a few large cavities surrounded by several larger ones. Fracture is tough and fibrous, and the odour is indistinct.

According to Shen-Miller, J. (2012) explained that fibrous roots first emerge from the base of a rudimentary radicle, and later extend outward from the developing nodes of rhizome. They serve as anchors, and they also absorb water and nutrients for lotus growth. Typically, they are bright red at emergence and become black-brown at maturity. Lotus is a perennial plant. It becomes dormant when day length shortens and temperature decreases; the plant top withers, but its underground stems (rhizomes) remain. Just how long individual rhizomes are able to survive is evidently unknown, but their renewal of lotus stands year after year goes on and on. Cultivar Sesame Lake is bred specifically for its edible rhizomes.

According to Shen-Miller, J. (2012) also explained that the primary rhizome of this cultivar, typically produced during a first growth season, is ~90 cm long, 5–6 cm wide, and has a total of 3–4 internodal segments. Each rhizome apex yellowish-jade in colour produces new rhizomes that themselves form new nodes and internodes. Over time, a single germinated fruit can thus produce a network of primary, secondary, tertiary, etc. rhizomes; and their aerial axes, leaves, and flowers form a dense stand of lotus throughout an entire shallow lake year after year.

According to Shen-Miller, J. (2012) also explained that yields of rhizomes can be as high as 4000–5000 kg ha-1. Propagation by rhizomes is the fastest and easiest means of reproduction in lotus cultivation. In China, newly propagated rhizome clumps planted in June can yield flowering lotus

plants the same season. Used commonly as food, the lotus rhizomes are said to have numerous medicinal values as well, many similar to those of leaves. Fresh rhizomes are thought to remedy ailments of the heart, spleen and stomach, as well as diarrhoea and bloody vomit. Rhizome powder is used to offset bleeding and lack of appetite; and rhizome nodes and fibrous roots are used as a remedy for nosebleed, as well as blood in urine, mucus and stools.

The lotus root is used to add seasoning to food. Lotus root is a moderate calorie root vegetable (100 g of root-stem provides about 74 calories) and is composed of several vitamins, minerals, and nutrients: 83.80% water, 0.11% fat, 1.56% reducing sugar, 0.41% sucrose, 2.70% crude protein, 9.25% starch, 0.80% fiber, 0.10% ash and 0.06% calcium.100 g of root provides 44 mg of vitamin C or 73% of daily recommended values (RDA).

According to Shukla, S., et al. (2018).explained that *Nelumbo nucifera* (lotus) is a medicinal plant in the monogeneric family Nelumbonaceae. Rhizome of lotus (lotus root) is recognized as one of the most delicious and nutritious vegetables in Asian countries along with its regular use in traditional medicine (Mukherjee et al. 2009; Huang et al. 2011). A number of studies have confirmed that lotus root contains high levels of polyphenolic compounds and possesses several beneficial health properties, such as hypoglycemic, anti-inflammatory and antioxidant potential (Yan et al. 2009).

According to Sridhar, K. R., et.al (2007) explained that the rhizome extract has anti-diabetic (Mukherjee et al., 1997a) and anti-inflammatory properties due to presence of asteroidal triterpenoid (Mukherjee et al., 1997b). Rhizomes are used for pharyngopathy, pectoralgia, spermatorrhoea, leucoderma, small pox, diarrehoea, dysentery and cough.

Lotus rhizome and its extracts have shown diuretic, psychopharmacological, anti-diabetic, anti-obesity, hypoglycemic, antipyretic and antioxidant activities. The antioxidant property of rhizome knot extracts has been reported to be higher than those from the whole rhizome (Sheikh, S. A. 2014).

According to Minh, N. P. (2019).explained that lotus rhizome powder, an antioxidant dietary fiber, could be used as an effective natural ingredient in meat products for the development of healthier and functional food.16 Extract of lotus root (Nelumbo nucifera rhizome) caused necrotic damage to human colorectal cancer cells in culture.14 There was a significant difference in total phenolic content and antioxidant activity between any two of four parts of lotus rhizome. The order of total phenolic content and antioxidant activity in different parts of lotus rhizome was as follows: peel of old lotus rhizome > peel of young lotus rhizome > flesh of old lotus rhizome > flesh of young lotus rhizome.

Minh, N. P. (2019) also explained that Nelumbo nucifera is grown naturally in the lakes. N. nucifera have been used for various medicinal purposes in various systems of medicine. The bioactive constituents of lotus are mainly alkaloids and flavonoids. The rhizome extract was used

as antidiabetic and anti-inflammatory properties due to the presence of asteroidal triterpenoid. We have successfully studied to produce one kind of instant soluble tea powder from lotus rhizome. In cultures where it occurs naturally it is known not only as a fragrant tea, but as having health and medicinal benefits as well. Lotus can be regarded as a potential nutraceutical source.

Lotus root beverage is commonly made from raw lotus root (RLR). However, RLR production is strictly limited, because it is prone to decomposition and browning after its short harvest season (Liu, J., et.al. 2010).)

According to Debra Rose Wilson, (2016), explained that lotus root is best suited for cooked applications such as steaming, frying, braising, stir-frying, and boiling. After peeling the root, it should be immersed in acidulated water using vinegar or citrus to prevent discoloration. Lotus root can be blanched just slightly to remove any bitterness, cooled, and added to salads or crudité. It can also be sliced and braised until tender in soups, stir-fried, battered and fried into tempura, or thinly sliced and baked into chips. In India, Lotus root is boiled, mashed, and added to vegetarian kofta, which is a dumpling dish paired with spicy sauces. A traditional Korean dessert also utilizes Lotus root with soy sauce, honey, and sesame seeds called yeongun bokkum.

According to Debra Rose Wilson, (2016), also explained that Lotus roots pair well with mushrooms, peppers, snap peas, snow peas, asparagus, corn, celery, cucumber, oyster sauce, peanuts, red beans, and sesame seeds. Lotus root will keep up to two weeks when stored whole, wrapped in damp paper towels, and placed in a plastic bag in the refrigerator. Sliced Lotus root

can be stored in an acidulated water solution for a couple of days, or it can be frozen for long-term storage. In addition to the symbolism of the flower, the Lotus root is believed to have a “cooling effect” on the blood and is used in traditional Chinese medicine for reducing body temperature while also stimulating the appetite. Lotus root powder, which the Chinese also eat for its medicinal effects, is simply lotus root that's been dried and finely ground. Boiling water is added to make a gelatinous, soup-like paste.

According to CCS HAU, H. (2019).explained that “Value-added “is simply anything we can do to raise the value of our product in the market. Value-added practices are key to future of sustainable farming, because they enable growers to advance economically without having to as:“pump-up” the production of raw materials from the land. USDA defines value addition as: A change in the physical state or form of the product (such as milling wheat into flour or making strawberries into jam).

According to CCS HAU, H. (2019).explained that the production of a product in a manner that enhances its value, as demonstrated through a business plan (such as organically produced products). As a result of the change in physical state or the manner in which the agricultural commodity or product is produced and segregated, the customer base for the commodity or product is expanded and a greater portion of revenue derived from the marketing, processing or physical segregation is made available to the producer of the commodity or product .

CCS HAU, H. (2019) also explained the advantages of value addition mainly consist of improve the profitability of farmer, reduces the glut in the market during peak season of produce; produce that cannot be stored can be converted into value added product increasing the profit; empower the farmers and other weaker sections of society especially women through gainful employment opportunities and revitalize rural communities; provide better quality, safe and branded foods to the consumers; odd looking fruits and vegetables (too big to too small in size, overripe, partially infected, etc) can be easily converted into value added products; emphasize primary and secondary processing.

CCS HAU, H. (2019) also explained about the advantages like reduce post-harvest losses; reduction of import and meeting export demands; way of increased foreign exchange; encourage growth of subsidiary industries; reduce the economic risk of marketing and finally increase opportunities for smaller farms and companies through the development of markets.

OBJECTIVES OF THE STUDY

The objectives of the study titled **"DEVELOPMENT AND POPULARISATION OF VALUE ADDED FOOD PRODUCTS USING LOTUS ROOT "**includes:

- To develop lotus root incorporated value added food product.
- To determine the most effective method for drying lotus root.
- To evaluate the organoleptic parameters and assess the sensory qualities.
- To determine the nutritional quality of the developed food products
- To assess the self-life stability of the developed food product for 3 months.
- To popularize and create awareness regarding health benefits of lotus root among adolescent girls of Thrissur district.

REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The review of literature pertaining to the study entitled 'Flower root: Development and popularization of lotus root. Incorporated food' is discussed under the following headings.

2.1 CULTIVATION AND UTILITY OF LOTUS ROOT

2.2 DESCRIPTION OF LOTUS ROOT

2.3 NUTRIENT COMPOSITION OF LOTUS ROOT

2.4 CHEMICAL PROPERTIES OF LOTUS ROOT

2.5 VALUE ADDED PRODUCT

2.6 HEALTH BENEFITS OF LOTUS ROOT

2.7 PHYSICOCHEMICAL PROPERTIES OF LOTUS ROOT

Fig 1

Fig 2

2.1 CULTIVATION AND UTILITY OF LOTUS ROOT

According to Sridhar, K. R., et al (2007) explained that Nelumbo nucifera belongs to the family of Nelumbonaceae, which has several common names (e.g. Indian lotus, Chinese water lilly and sacred lotus) and synonyms (Nelumbium nelumbo, N. speciosa, N. speciosum and Nymphaea nelumbo). Lotus is a perennial, large and rhizomatous aquatic herb with slender, elongated, branched, creeping stem consisting of nodal roots

.

According to Tian, D.et al. (2009) explained that lotus is usually planted in a tilled pond or rice field for vegetable production or planted in containers, small ponds, and lakes for ornamental uses. Planting time is often between late spring and early summer with plant growth ending in the fall under natural conditions. Growth and yield of lotus may be influenced by diverse factors such as genotype, media, water depth, light, temperature, planting time and propagation methods, planting techniques, fertilization, and other environmental factors.

Tian, D., et al (2009) also explained that cultivar selection and cultivation techniques are dependent on the environmental setting of the lotus plant. Lotus can be propagated by seeds, rhizome divisions with viable growing points, and tissue culture. Effects of propagation methods and planting techniques on yield of lotus have been much reported. Propagation by division of running stems (no enlarged rhizomes or straps) during the growing season cannot only save stock rhizomes and reduce cost, but also increase efficiency and prolong flowering period of plants and may replace plants that do not survive early in the year.

Tian, D., et al (2009) also explained that days to flowering are significantly shorter in the strap propagation method than in the enlarged rhizome propagation method where flowering time is delayed. Plants generated through the rhizome strap method also pro-duce larger flowers. Off-season cultivation methods have been developed to meet the demands of the market. Availability of vegetable rhizomes could be advanced to June by growing edible lotus earlier in the season (Fu et al., 1994). Flowering lotus generally blooms from June to August, but population flowering time can be extended to early October when lotus is propagated by dividing growing plants in July.

Tian, D., et al (2009) also explained about it's feasible to prolong flowering time of lotus through the winter when plants are planted in a heated green-house. If the technologies of advancing and delaying flowering are incorporated, three cycles of population flowering are possible in 1 year. Reports indicate that production of lotus cut flowers may be on a year-round schedule. However, little information is available on effects of planting time on overall lotus performance in various climatic regions. Productive organs of lotus plants are nutrient sinks. Disbudding of lotus would possibly increase plant yield of lotus rhizomes and other plant growth indices.

According to Yi, Y.et al (2016) has explained that lotus is found throughout India. It is widely found in the Bandhavgarh National Park, Eravikulam National Park in India. North of Kuttippuram offers beautiful sights of lotus cultivation on either side of the railway tracks. Lotus is cultivated on more than 20 acres in Thirunavaya and the village holds the distinction of the largest lotus farming done in a single spot in the State.

2.2 DESCRIPTION OF LOTUS ROOT

Lotus is a perennial aquatic plant. It belongs to the small family of Nelumbonaceae, comprising of only one genus Nelumbo with two species: Nelumbo nucifera Gaertn. and Nelumbo lutea Pear., which are popularly named as Asian lotus and American lotus, respectively. Generally, lotus refers to Asian lotus and mainly distributes in Asia and the north of Oceania, while the American lotus primarily occurs in the eastern and southern parts of North America, as well as the north of South America. Being separated by the Pacific Ocean, these two species differ in their external morphologies, such as petal color and shape, leaf shape and plant size In spite of this, both of them have the same chromosome number (2n = 16), and show a similar life style, with about five months of life span for each generation. Crossing between these two species could generate an F1 population, which is totally infertile. (Lin, Z., et.al 2019).

According to Shukla, S. (2018) explained that Nelumbo *nucifera* (lotus) is a medicinal plant in the monogeneric family Nelumbonaceae. Rhizome of lotus (lotus root) is recognized as one of the most delicious and nutritious vegetables in Asian countries along with its regular use in traditional medicine (Mukherjee et al. 2009; Huang et al. 2011). A number of studies have confirmed that lotus root contains high levels of polyphenolic compounds and possesses several beneficial health properties, such as hypoglycemic, anti-inflammatory and antioxidant potential.

According to Zhu, Y.et.al (2016) explained about the lotus roots are found buried in anaerobic sediment and are characterized by having oval holes for obtaining oxygen. Mevi-schutz and Grosse

conducted experiments that showed that thermoosmotic gas transport could drive oxygen flow from the lotus leaves to the roots. Mevi-schutz and Grosse also showed a lacunar pressure of up to 166 ± 44 Pa that could be measured in both young and old lotus leaves. The lotus root has a unique geometry with its canals regularly aligned. Through the study of the lotus root's porosity and orderly arranged pores, the lotus root has already provided engineering inspirations for the designs of a multibore hollow fibre membrane and a porous nanocomposite polymer electrolyte. It has also been applied to the development of porous carbon steels

According to Dominy,et. al (2008)explained that have studied the mechanical properties of plant underground storage organs. They found that rhizomes were the most resistant to deformation and fracture, followed by tubers, corms, and bulbs. They used a portable universal tester to estimate Young's modulus and fracture toughness of a range of plant species, with Young's modulus varying between 0.8 MPa and 18.7 MPa.

According to Shen-Miller, J. (2012) explains about the fibrous roots first emerge from the base of a rudimentary radicle, and later extend outward from the developing nodes of rhizomes They serve as anchors, and they also absorb water and nutrients for lotus growth. Typically, they are bright red at emergence and become black-brown at maturity. Lotus is a perennial plant. It becomes dormant when day length shortens and temperature decreases; the plant top withers, but its underground stems (rhizomes) remain. Just how long individual rhizomes are able to survive is evidently unknown, but their renewal of lotus stands year after year goes on and on. Cultivar Sesame Lake is bred specifically for its edible rhizomes.

Shen-Miller, J. (2012) also explains about the primary rhizome of this cultivar, typically produced during a first growth season, is ~90 cm long, 5–6 cm wide, and has a total of 3–4 internodal segments. Each rhizome apex yellowish-jade in colour, produces new rhizomes that themselves form new nodes and internodes. Over time, a single germinated fruit can thus produce a network of primary, secondary, tertiary, etc. rhizomes; and their aerial axes, leaves, and flowers form a dense stand of lotus throughout an entire shallow lake year after year. Yields of rhizomes can be as high as 4000–5000 kg ha-1.

Shen-Miller, J. (2012) also explains about the propagation by rhizomes is the fastest and easiest means of reproduction in lotus cultivation. In China, newly propagated rhizome clumps planted in June can yield flowering lotus plants the same season (Ni, 1987b). Used commonly as food, the lotus rhizomes are said to have numerous medicinal values as well, many similar to those of leaves. Fresh rhizomes are thought to remedy ailments of the heart, spleen and stomach, as well as diarrhoea and bloody vomit. Rhizome powder is used to offset bleeding and lack of appetite; and rhizome nodes and fibrous roots are used as a remedy for nosebleed, as well as blood in urine, mucus and stools (Huang, 1987b).

2.3 NUTRIENT COMPOSITION OF LOTUS ROOT

According to Sruthi, A., et.al (2019) explains about Lotus (Nelumbo nucifera Gaertn.) produces highly valued flowers and rhizome which is an underutilised vegetable. In addition, leaves, seeds, stems and other parts are edible and have many medicinal properties (Mukherjee et al., 2009). This plant is naturally seen as well as grown throughout the tropics. It has economic value where

rhizomes are popular because of its crispness, attractive white colour and abundant nutrients. They can be eaten either as cooked or raw form and are rich in health promoting compounds such as alkaloids, lipids, flavonols, carotenes, aporphine, nuciferine, phospholipids, flavonoids, xanthophylls, and minerals (Li et al., 2017)

According to Sruthi, A., et.al (2019) explains the identification and isolation of active phytocompounds is the preliminary step in designing plant based drugs. Plant extracts and bioactive compounds isolated from medicinal plants are used for antibacterial, antifungal and antiviral therapy.

According to Sruthi, A., et.al (2019) explain the quarter of the allopathic medications are based on compounds isolated from natural products. With increase in drug recalls resulting from severe side effects, the pharmaceutical industry also is interested in finding new drugs from natural sources with fewer or no side-effects. Recently, these traditional medicines are receiving more scientific support which helps in not only authenticating the use of these medicines for treatment but also understanding the mechanism of action of these drugs (Fernandes and Banu, 2012).

According to Tsuruta et al. (2012) reported that polyphenolic extract of lotus rhizome can alleviate hepatic steatosis in obese diabetic db/db mice. The condensed tannins present in lotus rhizome can relieves hepatic steatosis by suppressing the lipogenic enzyme activity in the liver of diabetes mice.

According to Zhao et al. (2014) identified the compounds astragaline, rutin, isoquercetin, nuciferine, dauricine, isoliensinine, and neferine. Lotus rhizome contains high levels of polysaccharides. Jiang et al. (2011) isolated two antioxidant micro-molecular components (gallocatechin, catechin) and an antioxidant macromolecular component LB2 from lotus rhizome.

According to Man, J.et. al (2012) explains about the lotus belongs to the Nelumbolaceae family and the genus Nelumbo. There are only 2 species in this genus: Nelumbo nucifera with pink, red or white flowers, distributed in Asia and Oceania, and Nelumbo lutea with yellow flowers, distributed in North and South America.

According to Sheikh, S. A. (2014).explains about the contents of fresh rhizome is described to have 81.42g water, 66kcal energy, 0.07g fat, 0.52g sugars, 1.58g protein, 3.1g fibre, 26mg calcium, 78mg phosphorus, 363mg potassium, 0.9mg iron The vitamins thiamine (0.12mg/100 g), riboflavin (0.01 mg/100 g), niacin (0.30mg/100 g) and ascorbic acid (27.4 mg/100 g) are also present in the rhizomes.

According to Fatima, T., et. al (2018) explains about the lotus rhizomes are rich in minerals and are consumed as health foods. It has profuse starch grains throughout the tissue. Fresh rhizome contains 31.2% starch, which shows no characteristic taste or odour.

According to Khattak, K. F., et. al. (2009) explains about the carbohydrate content of lotus was found to be 16.03 g and the carbohydrate content of lotus rhizome were 16.60 g/ 100g and it is

related to the value obtained in this study. Sheikh (2014) reported that content of carbohydrate in lotus rhizome was 16.02g.

Protein content of fresh lotus rhizome was found to be 2.60. This is in line with the observations of Khattak et al. (2009) and Mukherjee et al. (2009) who reported the content of protein in lotus rhizome of 2.41and 2.70 per cent. Paudel and Panth (2015) reported protein content of 1.70 per cent in lotus rhizome.

The fat content was found to be 0.10 g. Mukherjee et al. (2009) reported that the fat content of the fresh rhizome was 0.11 per cent and a similar findings of Sheikh (2014) revealed that the lotus root contained 0.07g of fat.

The fibre content were 4.20 per cent. Sheikh (2014) reported that lotus rhizome contain crude fibre of 3.10 g per 100g. Khattak et al. (2009) observed the fibre content to be 1.63g. Paudel et al (2015) reported fibre content of 0.80 per cent in lotus rhizome and it is less when compared to the fibre content of lotus rhizome in this study.

According to Sheikh (2014) explained the content of vitamin C were 38mg per 100g and reported that the ascorbic acid content of lotus rhizome as 27.4 mg. A similar findings of NIN (2002) revealed that vitamin C content of lotus rhizome was found to be 28mg per 100g. The total ash content in this study was observed to be 1.18 g. Mukherjee et al. (2009) stated that the ash content

of the fresh lotus rhizome was 1.10 per cent and it is also in the line with Khattak et al. (2009) who reported the ash content of lotus rhizome to be 1.22 per cent.

According to Faruk et al. (2012) explain the ash content of water chestnut was found to be 1.04% per 100g. Calcium content of lotus rhizome was found to be 40 mg per 100g. Sheikh (2014) reported calcium content of 27.4mg in lotus rhizome. Faruk et al. (2012) also stated that calcium content in water chestnut was 0.26% which was found to be low than the calcium content in lotus rhizome.

The iron content was observed to be 1.07 mg. A similar findings of Sheikh (2014) revealed that iron content in lotus root was 0.9mg. Mukherjee et al. (2009) reported the iron content of 0.05 per cent which was found to be low than the iron content in this study. The content of phosphorus was 58 mg. Sheikh (2014) stated that the phosphorus content of lotus rhizome was 78mg. Faruk et al. (2012) reported that the iron content of water chestnut was 6.77% per 100g.

According to Ríos, J. L., et al. (2018) explained that it had wide range of pharmacological activities in the fields of immunity and metabolism, namely antidiabetic, antihyperlipidemic, and anti-inflammatory antiviral and antitumor activities.The potassium was found to be 450mg in lotus rhizome and it is in the line with the observations of Sheikh (2014) who reported potassium of 363 mg per 100g.

Nutritional value per 100 g, Lotus root, cooked, no salt

Constituent Quantity Constituent Quantity Constituent Quantity

Energy	278 kJ (66 kcal)	Thiamine (B1)	0.127 mg	Calcium	26 mg
Carbohydrates	16.02 g	Riboflavin (B2)	0.01 mg	Iron	4.9 mg
Sugars	0.5.2 g	Niacin(B3)	0.3 mg	Magnesium	22 mg
Dietary fiber	3.1 g	Pantothenic acid (B5)	0.302 mg	Manganese	0.22 mg
Fat	0.07 g	Vitamin B6	0.218 mg	Phosphorus	78 mg
Protein	1.58 g	Folate (B9)	8 μg	Potassium	363 mg
Water	81.42 g	Choline	25.4 mg	Sodium	45 mg
		Vitamin C	27.4 mg	Zinc	0.33 mg

Source: USDA Nutrient Database

2.4 CHEMICAL PROPERTIES OF LOTUS ROOT

The mean moisture content in raw lotus rhizome was found to be 72.14 per cent. Moisture content of 75.40 per cent and 77.58 per cent were reported by Li et al. (2017) and Khattak et al. (2009) in lotus root. Mukherjee et al. (2009) found moisture content of 83.80 per cent of lotus rhizomeThe starch content of lotus rhizome was found to be 10.05 per cent.

According to Mukherjee et al. (2009) explain the starch content of the fresh rhizome was 9.25 per cent which is observed to be slightly lower than the starch value obtained in this study. Faruk et al. (2012) reported that the starch content of water chestnut was 8.7 per cent.

According to Syed et al. (2012) explained that the fresh lotus root contained 15 per cent of starch and it can be used in the manufacturing of food products such as imparting texture and consistency and as functional ingredients like thickeners, stabilizers and gelling agent. According to Geng et al. (2007) explained that lotus starches had highest percentage of amylose 21.16 per cent and possessed good clarity and gel strength.

According to Sruthi, A., et .al(2019)HR-LCMS analysis of methanol extract of Nelumbo nucifera rhizome showed 6 major peaks indicating the presence of various phytochemical constituents. On comparison of the high resolution liquid chromatography and mass spectra of constituents with the main library all these compounds were characterised and probably identified. Identified compounds were Betulinic acid, Rutin, Isoquercetin, 2R - aminohexadecanoic acid,

Phytosphingosine, Sphinganine, Phorbol, Ginkgolide B, Tetrahydroxy- 2,6- dimethyl anthroquinone, Pseudouridine, p – Hydroxyphenobarbital, Fluoroacetate, Isoamyl nitrite, Metronidazole, Napthaldehyde, Acetoin.Betulinic acid is a triterpenoid isolated from birch trees and even found in other botanical sources (Czuk, 2014).

Rios et al (2018) stated that it had wide range of pharmacological activities in the fields of immunity and metabolism, namely antidiabetic, antihyperlipidemic, and anti-inflammatory antiviral and antitumor activities.

According to Zhou et al. (2014) explained that isoquercetin had numerous therapeutic properties, including anti-inflammatory, antioxidant and anti-allergic activities. Morand et al. (2000) also demonstrated that isoquercetin was better absorbed than quercetin and had higher bioavailability. Harborne (1986) described that rutin is a flavonol, abundantly found in plants, and is a vital nutritional component of food stuff.

According to Ganeshpurkar et al (2017) explained that it contained a number of pharmacological activities, including antioxidant, cytoprotective, vasoprotective, anticarcinogenic, neuroprotective and cardioprotective activities.

According to de Jesús Cortés-Sánchez,et.al (2013)explain about the phytosphingosine is an endogenous, bioactive sphingolipid present in fungi, plants, and the corneous layer of human skin

in low concentrations. It possessed antimicrobial and antitumor property. Lloyd-Evans et al. (2008) suggested the possibility that endogenous sphinganine may inhibit cholesterol transport in Niemann-Pick Type C (NPC) disease.

According to Van den Broek et al. (2012) explained that administration of phenobarbital under hypothermia reduced the transition rate from a continuous normal voltage (CNV) to discontinuous normal voltage in hypothermic asphyxiated newborns, which may be attributed to the additional neuroprotection of phenobarbital in infants with a CNV pattern. Metronidazole played an important role in anaerobic- related infections and proved to be an antibiotic (Lamp, 1997).

Amyl nitrite are used in the treatments of hypertension or ischemic heart disease, and was discovered to possess novel pharmacologic actions such as modulating hypoxic vasodilation and providing cytoprotection in ischemiareperfusion injury (Nossaman et al., 2010). According to Ramdas et al., (2006) explained that the phytochemical plays an important role in the treatment of diseases without any side effects, there is a need to search new drugs from natural sources.

According to Bond et al. (2007) explain that administration of phorbol myristate acetate can act effectively against pancreatic cancer. Anthraquinones constitute an important class of natural and synthetic compounds used as colorants. Anthraquinone derivatives have been used as laxatives, antimicrobial and anti-inflammatory agents. Current therapeutic indications included constipation, arthritis, multiple sclerosis, and cancer (Malik et al, 2016).

2.5 VALUE ADDED PRODUCT

Lotus root can be prepared in a variety of ways, but it is most often cooked prior to consumption. After peeling the Lotus root it should be immersed in acidulated water (using vinegar or citrus) to prevent discoloration. Lotus root can be blanched just slightly to remove any bitterness and cooled to add to salads or crudite. Lotus root is very common in Asian and Indian dishes, whether sliced and braised until sweet and tender in soups, stir fried, or sliced, blanched and chilled to garnish salads. Lotus root is boiled and mashed in India and added to vegetarian kofta, paired with spicy sauces.

It can be thinly sliced or shredded and fried for a crispy garnish. Lotus root pairs well with traditional Asian flavors such as soy, sesame, and ginger. A traditional Korean dessert is made with Lotus root, soy, and honey and sesame seeds called Yeongun bokkum. Lotus root can be stored peeled in the water solution for a couple of days, or frozen for long-term storage. Lotus root can be stored fresh and whole in a cool, dry place for up to two weeks. Dried Lotus root can be powdered and used as a starch.

According to Qi-xing, et.al (2007)explained .,there are some major industrial products of lotus root in China, which are salted or boiled for exporting as well as lotus root starch and lotus juice for domestic sale. But the convenient food from lotus root cannot meet demand of the growing domestic market. The application of quick-freezing technology, reconstruct-extrusion technology, sterilization and microencapsulating technology were investigated to the development of convenient food and comprehensive utilization of waste from lotus root processing, so that the

convenient foods were mainly produced such as prepared flavor and ready-to-eat lotus. Lotus industrialized production technology was attempted. New technology will be a strong impetus to the development of the industry of lotus produce in China

Lotus (*Nelumbo nucifera*) root has been used as an edible vegetable in East Asia for thousands of years. The present research was aimed to explore the physicochemical, nutritional and microbiological safety of lotus root fermented sugar syrup as a fermented food supplement or condiment for human health benefits.

Lotus powder made of dried lotus root can be used to make porridge. It has a lot of health benefits too. Kerala Agricultural University developed lotus biscuit made of lotus root powder and wheat powder (Vimal Kottakkal , 2020). Lotus root powder, which the Chinese also eat for its medicinal effects, is simply lotus root that's been dried and finely ground. Boiling water is added to make a gelatinous, soup-like paste.

According to Shukla,et.al (2018) explained Lotus (*Nelumbo nucifera*) root has been used as an edible vegetable in East Asia for thousands of years. All the lotus root fermented sugar syrup samples were subjected to microbiological analysis. It was found that the coliform, *Bacillus cereus*, *Escherichia coli*, *Salmonella* and *Staphylococcus aureus* counts were not detected in majority of the samples, confirming the high degree of hygiene processing of lotus root fermented sugar syrup samples for its use as a food supplement or condiment.

Lotus root that is heavy and firm, with no soft spots or bruising. Once the stem has been peeled, soak it in vinegar to preserve its pale-colored flesh. Packages of cut and sliced lotus root, which often come in a solution of water and salt, can be used in the same way as fresh lotus root. Lotus seeds are usually sold in dried form at Chinese stores and resemble chickpeas in color and shape.

A classic preparation for lotus root is stir-frying, which highlights the crunchy yet tender texture of the stem. When stir-frying lotus root, pair it with other vegetables that are also tender and crisp, such as sugar snap peas, snow peas, asparagus, and celery. I typically stir-fry lotus root with plenty of wine and oyster sauce, which adds much needed depth to the mild taste of the stem. Like so many other tubers and stems, lotus root is a welcome addition to soups and stews, absorbing whatever flavors are in the simmering liquid. (Chichi-wang, 2010)

According to Ham, et.al(2005).explained about the. Lotus beverage on phenylephrine induced contraction of isolated rat thoracic aorta. Contractile force was measured with force displacement thansducer under 1.5g loading tension. Brix, pH and titratable acidity of developed drink were 12.25%, 4.5 and 0.092%. The approximate nutritional composition of beverage was carbohydrate, 9.40%, crude protein, 0.30%, crude fat, 0.25% and ash, 0.15%. Also insoluble fiber and soluble fiber were 1.30%, 0.80%. Developed beverage contained Na(11.45 mg%), K(6.87 mg%), Ca(2.53 mg%). The contraction forces by injection of phenylephrine in isolated thoracic aorta were significantly law in each beverage treatment groups compared with control group. These results that developed drink with medicinal plants can be used as a functional material to decrease aorta contraction.

According to Park, et.al (2008) explained that lotus root powder were added to the wheat flour to prepare the dried noodles. The cooking quality, mechanical textural properties, and viscosity were measured, and a sensory evaluation was conducted with the prepared noodles. The gelatinization points of the composite Lotus root powder-wheat flours were shown to have increased and the viscosity at , viscosity at after 15 minutes .With regard to the textural characteristics, the Lotus root powder additive increased hardness and reduced adhesiveness, cohesiveness, and springiness. Overall, the noodles prepared with 15% Lotus root powder were preferred more than the other noodles, according to the results of our sensory evaluation.

According to Kim,et.al (2011)explained that the lotus powder were added to the batter based on flour content. Baking and cooling loss rate, volume and specific loaf volume, crumb color, texture, scanning electron microscopy (SEM) and sensory evaluation of the products were analyzed. The baking and cooling loss rate of the control was lower than cakes with added lotus leaf and lotus root powder. The volume of the control was the largest, and as the amount of lotus leaf and lotus root powder increased, volume and specific loaf volume became smaller. The lightness and yellowness values of the control were higher than those of the experimental cakes, and the loaves with 12% added lotus root powder showed the lowest value. Redness of the experimental cakes increased. In a sensory evaluation, sponge cakes containing lotus root powder were preferred rather than those with lotus leaf powder. As a result, good sponge cakes were prepared by adding 4% lotus leaf powder or 8% lotus root powder.

According to Malia Frey (2020) explains that Lotus root is used in a variety of Asian dishes, especially Japanese cuisine. Two common methods of cooking include stir-frying and steaming. It's also a popular addition to soups. You can also candy or deep fry lotus root, but these less healthy preparation methods can take away from some of its beneficial properties. Healthy Lotus Root Recipes to Try : Easy Asian Broccoli Stir-Fry Recipe ,Miso Marinated Steak With Bok Choy Stir-Fry, Asian Chopped Salad Recipe With Garlic-Ginger Chicken ,Asian Peanut Noodle Salad ,Bok Choy and Oyster Mushroom Stir-Fry

Eden Foods is a principled natural food company, est. 1968. Healthy soil, long-term organic, non-GMO, skilled growers and handlers; a reliable alternative to commercial food. Uncompromised, pure, most delicious nutrient rich lotus root tea. Dried, ground root of the esteemed Asian water lily, treasured for contributing to respiratory health. This root is commonly sliced and pickled, sautéed or baked. It has a mildly sweet taste that’s been likened to that of water chestnuts with a nutty flavor and a texture similar to potato. Lotus root also has a satisfying crunch when it’s cooked, so it makes for an excellent snack (think lotus root chips) or addition to stir-fries. The root is also used to make lotus root starch, or it’s dried to make a powder that’s used in Chinese medicine. (Eden Foods Company)

2.6 HEALTH BENEFITS OF LOTUS ROOT

Lotus rhizome and its extracts have shown diuretic, psychopharmacological, anti-diabetic, anti-obesity, hypoglycemic, antipyretic and antioxidant activities. The antioxidant property of rhizome knot extracts has been reported to be higher than those from the whole rhizome. Ethno-Medicinal Uses and Pharmacological Activities of *Nelumbo Nucifera* Rhizome: Diuretic activity,

Antidiabetic,Antioxidant, Anti-inflammatory, Immunomodulatory and Psychopharmacological; Rhizome extract: Anti-diabetic and Anti-obesity; Flowers Rhizome Hypoglycemic Antipyretic activity. (Subzar Ahmad Sheikh, 2014).

According to Christine Ruggeri(2018) explain that lotus root Promotes Glowing Skin, Boosts Brain Health, Supports Energy Levels, Aids Digestion and Weight Management, Improves Cardiovascular Health and Boosts Immunity.

According to Raghavan, S (2017) explains that .Lotus root contains tannin, an astringent substance that has a lot of liver-protecting qualities. A study conducted by Tsuruta et all in 2011 revealed that the condensed tannin present in the roots improved liver conditions such as hepatomegaly (enlarged liver) and nonalcoholic fatty liver disease.

Nelumbo nucifera have astringent, diuretic, emollient, antifungal, antimicrobial, antipyretic, antibacterial, and anti-steroidal, cardiotonic, antiviral, anticancer, anthelmintic, anti-obesity properties. Lotus root has a significant content of iron and copper, and they play a major role in the production of red blood cells, decrease the risk of developing symptoms of anemia and increase blood flow. Hence, this root helps in stimulating blood circulation and increases organ oxygenation. It also boosts functionality, vitality and energy levels because the circulation of blood is well stimulated. (Renu M, 2019)

According to Sarika Rana(2018) explains that Lotus root has high amounts of dietary fiber, which helps boost digestion. The presence of significant levels of potassium in lotus roots ensures a balance between fluids in the body and prevents excessive sodium from affecting the bloodstream. It relaxes the blood vessels and further prevents contraction and rigidity, increasing blood circulation. The iron present in the lotus roots also helps in smooth blood circulation. Lotus roots

have vitamin B complex, which has a compound known as pyridoxine. This compound interacts with neural receptors in the brain, which are responsible to reduce stress, irritability and headaches. Basically, lotus flower gets its peace and tranquility power from its roots. The excessive potassium content in lotus roots absorbs the excess sodium and increases the production of urine. Thus, the roots help in preventing excess water retention.

2.7 PHYSICOCHEMICAL PROPERTIES OF LOTUS ROOT

Starches extracted from lotus rhizomes are commercially available in China and consumed as breakfast, fast food, traditional confectionery, and food additives (Zhong et al. 2007). Starches from different botanical sources have diverse physicochemical and functional properties, and are greatly affected by environmental conditions. At present, most studies have been focused on corn, rice, wheat, potato, and tapioca starches. The purpose of this study was to investigate the structure, morphological, thermal, and pasting properties of starches extracted from lotus rhizomes planted in the southeast area of China.

According to Shuyi Li ,et al , (2016)explained that the effects of boiling and steaming on lotus root volatile compounds and some of its physicochemical properties were determined. A total of 52 compounds identified in the raw tuber by GC-MS were a combination of the rhizome's native compounds and those from the soil and water environment, and are predominantly a mixture of straight chain and cyclic alkanes, and aromatic hydrocarbons. Boiling increased concentrations of most of these compounds, unlike steaming that lowered total volatile components of the tuber.

Cooking increased complexity of volatile compounds with the production of new compounds such as methylated derivatives, particularly in steam cooked lotus. Other heat-induced compounds include antioxidants such as butylated hydroxyl compounds and antifungal organic compounds such as dimethyl disulfide. Instrumental texture measurements indicate that the characteristic post-cooked retention of crunchiness in lotus root is likely to be related to retention of its springiness index through the cooking process (Shuyi Li ,et al , 2016).

Phytosphingosine is an endogenous, bioactive sphingolipid present in fungi, plants, and the corneous layer of human skin in low concentrations. It possessed antimicrobial and antitumor property (De Jesus Cortes-Sanchez et al., 2013).

According Lloyd-Evans et al. (2008) explained the possibility that endogenous sphinganine may inhibit cholesterol transport in Niemann-Pick Type C (NPC) disease.

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normal voltage in hypothermic asphyxiated newborns, which may be attributed to the additional neuroprotection of phenobarbital in infants with a CNV pattern.

Metronidazole played an important role in anaerobic- related infections and proved to be an antibiotic (Lamp, 1997). Amyl nitrite are used in the treatments of hypertension or ischemic heart disease, and was discovered to possess novel pharmacologic actions such as modulating hypoxic vasodilation and providing cytoprotection in ischemiareperfusion injury (Nossaman et al., 2010). Ramdas et al., (2006) revealed that the phytochemical plays an important role in the treatment of diseases without any side effects, there is a need to search new drugs from natural sources.

METHODOLOGY

CHAPTER-3

METHODOLOGY

Research Methodology is defined by Goundar, S. (2012).as ".Research methodology is a collective term for the structured process of conducting research. There are many different methodologies used in various types of research and the term is usually considered to include research design, data gathering and data analysis. Research methodology seeks to inform: Why a research study has been undertaken, how the research problem has been defined, in what way and why the hypothesis has been formulated, what data have been collected and what particular method has been adopted, why particular technique of analyzing data has been used and a host of similar other questions are usually answered when we talk of research methodology concerning a research problem or study.

Goundar, S. (2012) also explained research methodologies can be quantitative (for example, measuring the number of times someone does something under certain conditions) or qualitative (for example, asking people how they feel about a certain situation). Ideally, comprehensive research should try to incorporate both qualitative and quantitative methodologies but this is not always possible, usually due to time and financial constraints. Research methodologies are generally used in academic research to test hypotheses or theories. A good design should ensure the research is valid, i.e. it clearly tests the hypothesis and not extraneous variables, and that the research is reliable, i.e. it yields consistent results every time.

A The methodology of the present study **"Development and popularization of value added food product using Lotus Root (*Nelumbo nucifera)*"** is discussed under following phases;

3.1 Development of indigenous products based on Lotus Root (*Nelumbo nucifera)*

3.1.1 **Selection of Lotus Root for the study**

Nelumbo nucifera, also known as Indian lotus, a flower where all parts are being utilised and highly health beneficial. Species of aquatic plant in the family Nelumbonaceae. They are much available and they can be cultivated in a cheap and easy way. Most of the people were ignorant about the nutritive value of Lotus root powder consumption rate among the people was very less but availability was also found to be more. Thus Lotus root powder was chosen for the study which involves development of Lotus root incorporated recipes and its popularization among the adolescent groups belonging to Thrissur.

3.1.2 Selection of recipes for Lotus root incorporation

Four recipes suitable for Lotus root incorporation were collected and 4 ideal recipes were selected for the study. The recipes selected for incorporation were Lotus root cookies, Lotus root cake, Lotus root nutrition bar and Lotus root health mix. The best product gained is lotus root cookies.

3.1.3 Organoleptic evaluation of incorporated products

Quality is the ultimate criterion of the desirability of any food product. Organoleptic evaluation is a scientific discipline used to evoke, measure and analyse reactions to those characteristics of products or material as they are perceived by the sense of sight, smell, taste, touch and hearing. The developed products were evaluated organoleptically to assess their sensory qualities

3.1.4.1 Selection of judging panel

To assess the acceptability of the products through sensory evaluation, a panel of 24 members was selected. The selection criteria for the panel members were their ability to perceive and recognize the variations in the quality of different food items. For the selection of panel members serial dilution test was used. A small highly sensitive panel would give more reliable results than large less sensitive groups. Twenty four of the participants who got highest scores were selected as the judging panel.

Plate 1

Plate 2

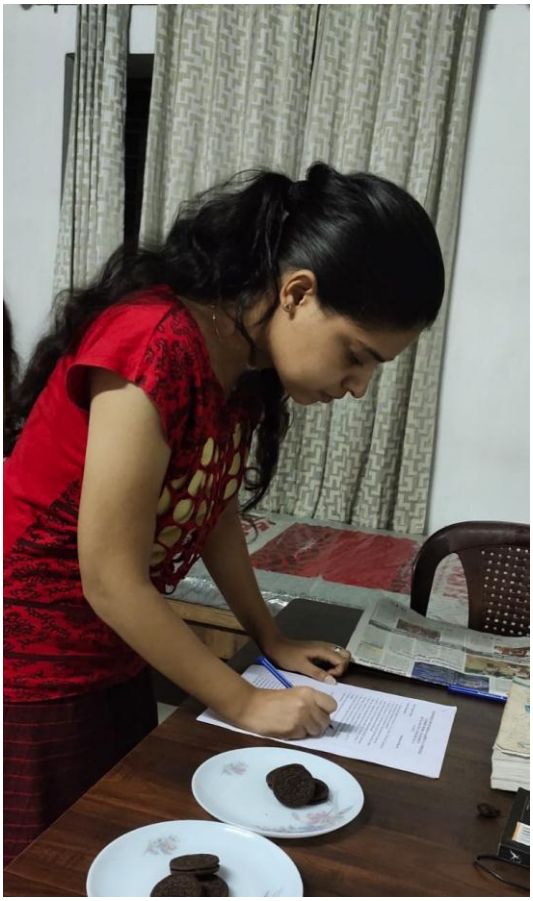


Plate 3

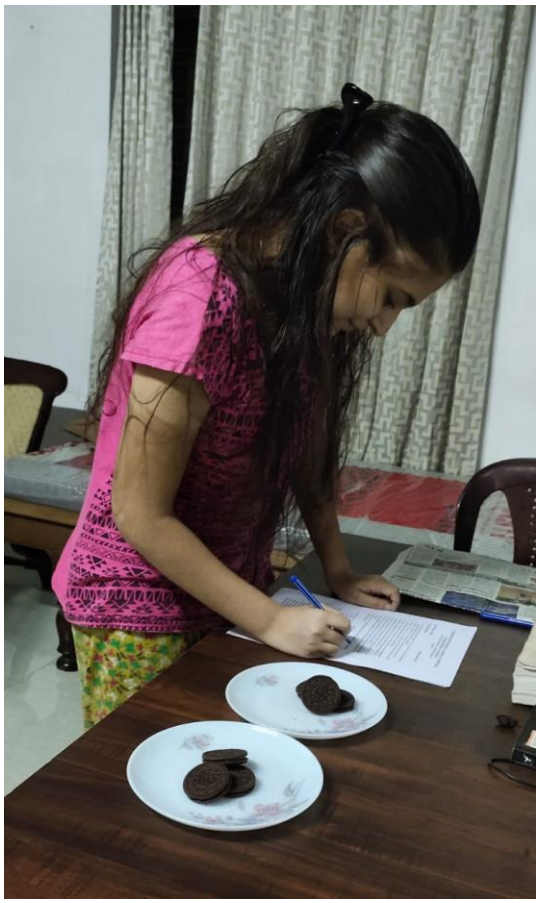


Plate 4

3.1.4.2 Formulation of different combination of products and selecting the best one

Before the preparation of the items, Lotus root was exposed to different pre-treatments like dehydration, extraction of juice etc. according to the need. Three different variations of each product were prepared with Lotus root incorporated at 20, 30, and 50 per cent. The incorporated products were evaluated organoleptically by the selected judging panel.

3.1.4.2.1 PREPARATION OF LOTUS ROOT FLOUR

Before the preparation of the items lotus root was exposed to different methods of drying like sun drying, oven drying and pan drying

3.1.4.2. (a) Preparation of lotus root flour by sun drying

The lotus root was cleaned and boiled for 10 minutes. Then they are cooled and sliced into slightly thin slices and then they are kept under the direct sun light for drying. These are kept for 2 weeks to properly dehydrate to remove the moisture content. The lotus root are then powdered into fine powder. The appearance, quality, texture, taste and color was retained and obtained in good quality.

3.1.4.2. (b) Preparation of lotus root flour by oven drying

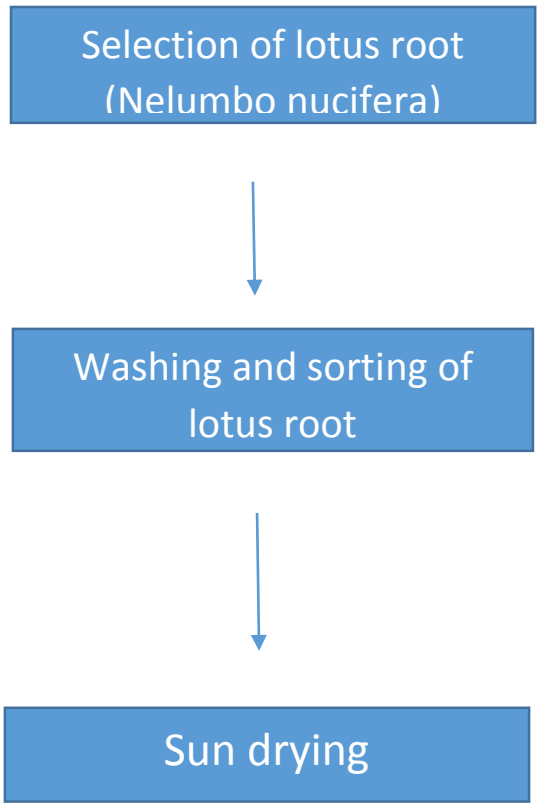
The lotus root was washed and cleaned thoroughly. Then they are sliced into slightly thin slices.

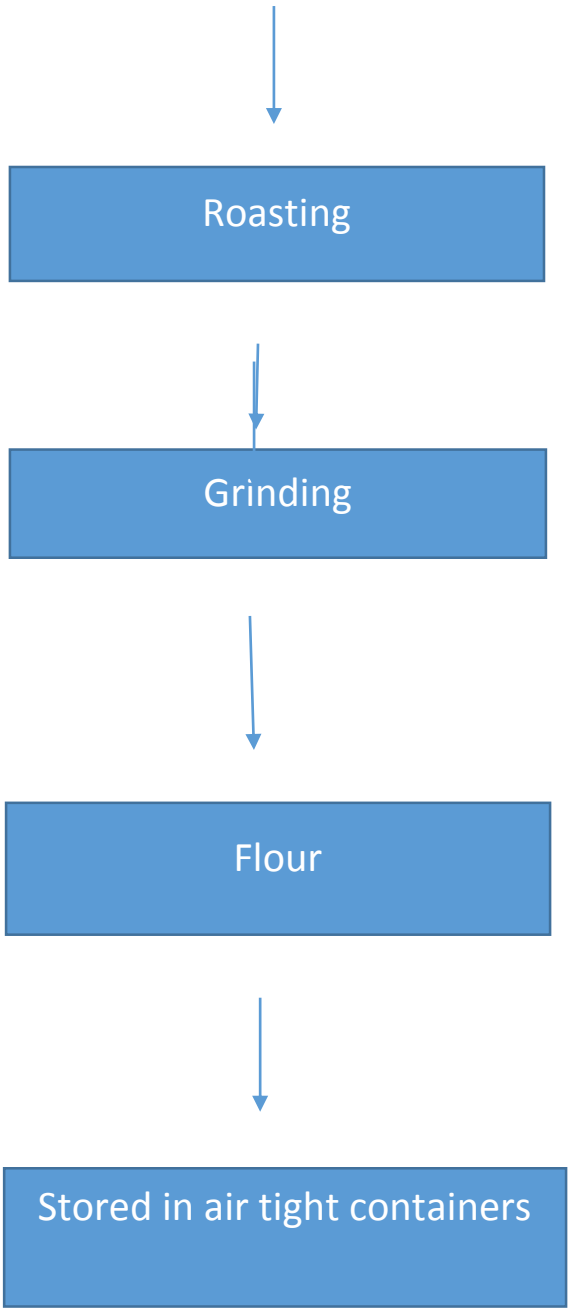
Then they are placed in trays to place in oven. The oven was preheated for 20 minutes at 200 C.

Then they are kept for 30 minutes to dry the lotus root. Then they are cooled down for a while and then they are grinded into fine powdered form. The color, quality and appearance was maintained. But the texture and taste was slightly not up to the mark as they are more drying and the taste have changed.

3.1.4.2. (c) Preparation of lotus root flour by pan drying

The lotus root was washed and cleaned thoroughly. Then they are cut into slices and they are placed into pan while heating and the moisture was dried up with the help of heat from the pan. These lotus roots are dehydrated well and then cooled down to grind them into fine powder. The color, texture and taste is not maintained. As they have lost the color, texture and taste of the flour.




Roasting
Grinding
Flour
Stored in air tight containers

3.1.4.2.2 DEVELOPMENT OF LOTUS ROOT FOOD PRODUCTS

3.1.4.2.2 (a). Procedure for developing Lotus root cookies.

Before preparation, the organoleptic properties of Lotus root powder is checked such as condition of root, expiry date of other ingredients used etc. Lotus root were washed and boiled in hot water. The other ingredients required for preparation of food were placed near such as wheat, butter, sugar and milk. All the ingredients were measured using a weighing balance. Handling and preparation of the food product is done under hygienic conditions with minimum wastage of food materials.

INGREDIENTS

The health fullness of a food depends on the ingredients used in the foods preparation.

NO.1 COCO LOTUS ROOT COOKIES

INGREDIENTS:

1. Wheat flour - 70 gms
2. Lotus root powder - 30 gms
3. Butter - 25 gms
4. Powder sugar - 50 gms
5. Milk - 15 ml
6. Baking powder - 1STD
7. Baking soda - ¼ STD
8. Salt - a pinch

METHOD OF PREPARATION

1. Lotus roots are boiled in water and cut into small pieces and sun dried to obtain the lotus root powder.
2. Take all the raw and wet ingredients.
3. In a bowl add butter and sugar and mix them well.
4. Add wheat flour, lotus root powder, baking powder and baking soda together and sieve well.
5. Then add the dry ingredient to wet ingredients and mix well.
6. A pinch of salt is added to the mixture.
7. Make the dough into shapes, or balls and place them on the baking tray.
8. Bake them for 15 minutes at 160 C.
9. They are cooled down and packed with care.

Plate 5

Ingredients of lotus root cookies

Plate 6

Variation of lotus root cookies

Plate 7

Labelling of lotus root cookies

3.1.4.2.2 (b). Procedure for developing of Lotus root cake

NO.2 COCO LOTUS ROOT CAKE

INGREDIENTS

1. Wheat flour 70 gm
2. Lotus root powder 50 gm
3. Jaggery 50 gm
4. Dates 5 gm
5. Oil 40 ml
6. Baking powder 1 ½ STD
7. Baking soda ¼ STD
8. Vanilla essence 1 STD

METHOD OF PREPARATION

1. Lotus roots are boiled in water and cut into small pieces and sun dried to obtain the lotus root powder.
2. Take all the raw and wet ingredients.
3. Add wheat flour and lotus root powder well. Then add baking powder and baking soda.
4. Melt the jaggery with water and remove the dirt and dust.
5. Mix the flour and jaggery. Then add oil and mix them well.
6. Add vanilla essence and dates and mix again.
7. Pour the batter into the cake tray and bake it for 30 minutes at 180 C.
8. After cooling pack the product and seal.

Plate 8

Ingredients of lotus root cake

Plate 9

Variations of lotus root cake

Plate 10

Labelling of lotus root cake

3.1.4.2.2 (c). Procedure for developing Lotus root powder nutrition bar

NO. 3 COCO LOTUS ROOT NUTRITION BAR

INGREDIENTS

1. Oats 70 gms
2. Lotus root powder 30 gms
3. Dates 20 gms
4. Cashew 40 gms
5. Almond 40 gms
6. Watermelon seeds 20 gms
7. Sesame 20 gms
8. Honey 100 ml

METHOD OF PREPARATION

1. Lotus roots are boiled in water and cut into small pieces and sun dried to obtain the lotus root powder.
2. Roast the oats and then make them into fine powder.
3. Cashew, almond, watermelon seeds and sesame roast them at low flame and the remove when they turns aromatic.
4. Add both the mixture together along with the sliced dates
5. Then mix the honey and mix them thoroughly.
6. Place them in a tray and keep them aside for setting.
7. Cut them after cooling and pack them.

Plate 11

Ingredients of lotus root nutri bar

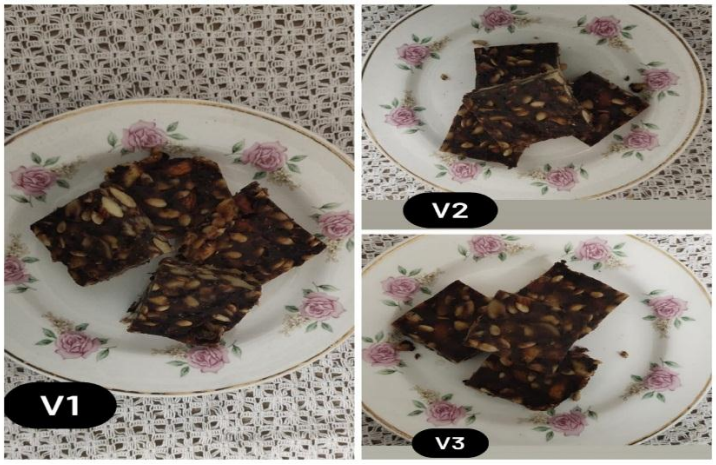


Plate 12

Variations of lotus root nutri bar

Plate 13

Labelling of lotus root nutri bar

3.1.4.2.2 (d). Procedure for developing Lotus root health mix

NO. 4 COCO LOTUS ROOT HEALTH MIX

INGREDIENTS

1. Roasted gram 70 gms
2. Lotus root powder 20 gms
3. Green gram 20 gms
4. Cashew 10 gms
5. Oats 30 gms

METHOD OF PREPARATION

1. Lotus roots are boiled in water and cut into small pieces and sun dried to obtain the lotus root powder
2. Roast the green gram, oats, roasted gram and cashew separately in low flame.
3. Then powder these ingredients after cooling down
4. Then mix all the powder together along with lotus root powder.
5. Then pack the powder mix in air tight container

Plate 14

Ingredients of lotus root health mix

Plate 15

Variations of lotus root health mix

Plate 16

Labelling of lotus root health mix

3.1.4.3 Standardization and sensory evaluation of the developed products The Lotus root powder were incorporated at percentages of 20, 30 and 50 to the selected products to form three variations each namely A, B, and C. Triangle test was employed for selecting the best variation out of the three . In this test, a five point score card which evaluates the factors like taste, colour, flavour, texture and appearance were given to the judging panel. Each members of the judging panel tasted and evaluated the products and marked their score in the score card.

3.2. Nutritive value of formulated recipes The nutrient content of the developed products per 100g were calculated using Nutrient Composition Table and lab testing results using standard testing procedures with reference to their Dietary fibre, Iron, Carbohydrate ,Calcium and Protein content.

3.3. Shelf life study

The developed products were analysed for their shelf stability for a period of 3 months. The variations of each prepared products were stored in glass bottles plastic containers at room temperature and were analysed for their shelf life. During the storage period, the bottles were examined visually for detecting any colour change or microbial deterioration. At the end of each month, one set of each variation of the stored products was evaluated for their sensory qualities also.

3.4. Evaluation of time for the preparation of Lotus root incorporated food products

The time taken for preparing 100g of each products with higher overall acceptability scores were assessed for measuring the easiness with which the products were prepared. It was calculated on the basis of the time taken for preliminary preparations and the time taken for cooking the products.

3.5. Popularization of products

Out of the four developed products, four products which obtained the highest scores were popularized among the selected adolescent groups belonging to Thrissur, was selected and thus encouraging them to start consuming.

3.5.1. Selection of products for popularization

For the purpose of popularization, two best recipes were selected from the four Lotus root incorporated products. The four products which got the highest score for overall acceptability when organoleptically evaluated were selected for popularization.

3.5.2. Selection of consumer group for the popularization of products

Lotus root incorporated recipes were popularized among adolescent belonging to self-help groups like adolescent groups, through demonstrations and lectures, thus encouraging them to start consuming Lotus root which have high medicinal and nutritive value, in easier and cost effective ways.

3.5.3. Formulation of brochure and charts for popularization

Brochure and charts which contained necessary information, nutritional benefits and medicinal uses of Lotus root were prepared and given to the members of adolescent group for the process of popularization.

3.5.4. Formulation of questionnaires for popularization

For the process of popularization, questionnaires were prepared to checking the awareness of the adolescent groups and to collect the details regarding the extent of knowledge, the consumers attained through the lecture

Plate 17

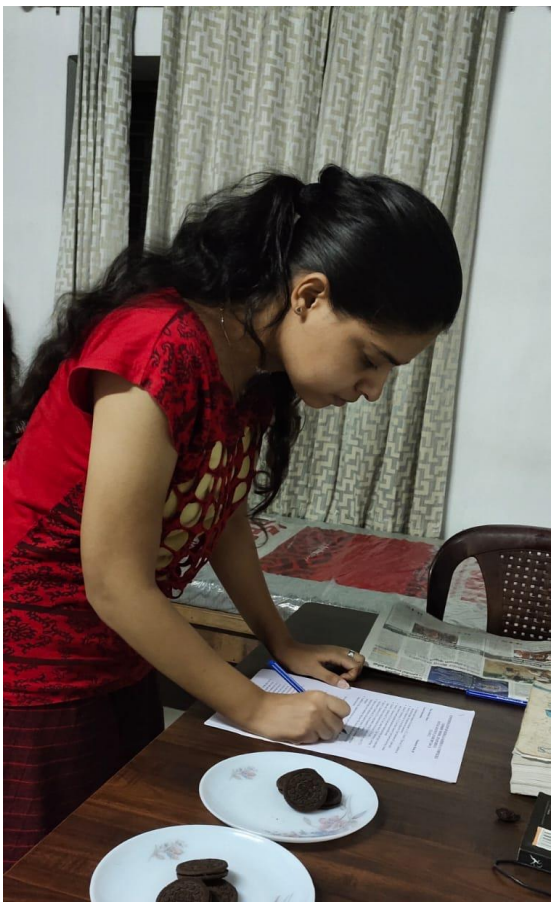


Plate 18

RESULT AND DISCUSSION

CHAPTER-4

RESULT AND DISCUSSION

The study of 'Development and popularisation of value added food product using Lotus root **(*Nelumbo nucifera*)**' was statistically analysed and discussed under the following headings:

4.1 DEMOGRAPHIC PROFILE OF THE SELECTED SUBJECTS

4.1.1 Age profile of selected subjects

TABLE-1

Age	Number	Percentage
14- 15	24	24
16- 17	39	39
18- 19	37	37
Total	100	100

In the age profile of selected subjects for studying the family food habits along with the graphical representation group were depicted in the TABLE-1, about 24% of subjects were seen in the age group 14- 15 years, 39% of subjects seen in the age group16- 17 years and 37% in age group18- 19 years.

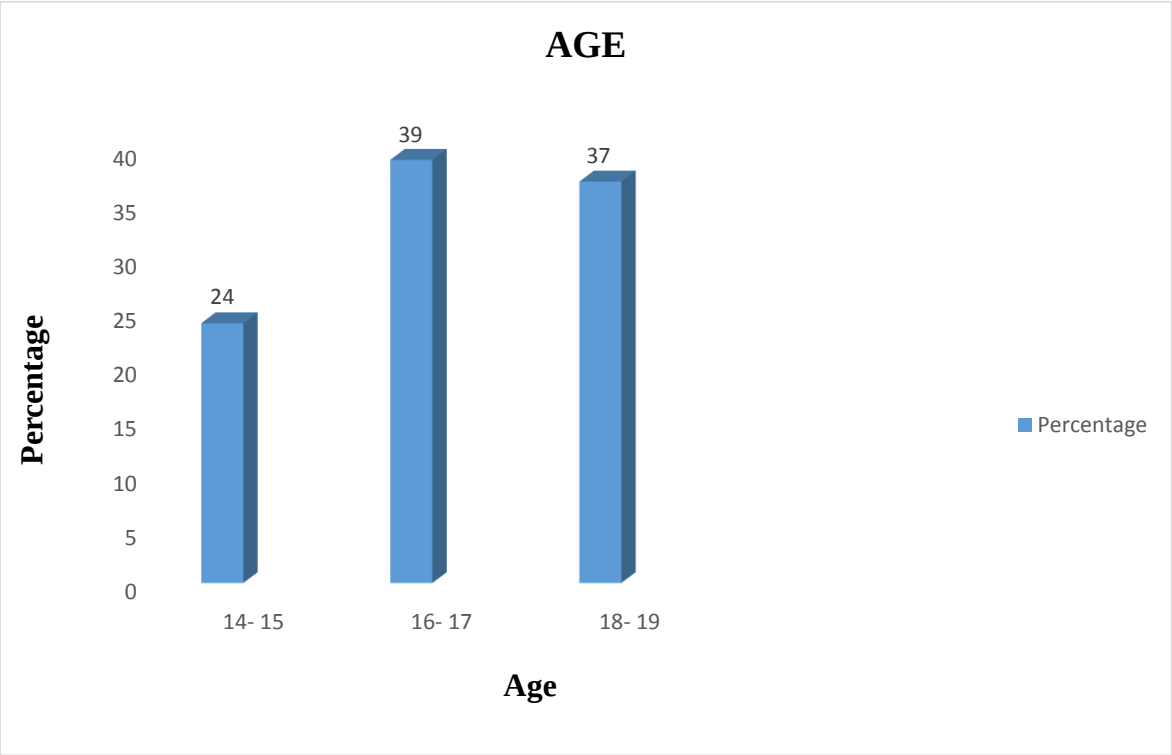


Fig 1

Age profile of selected subjects

4.2 CULTIVATION OF LOTUS ROOT IN SELECTED SUBJECTS

4.2.1 Cultivation of Lotus root in your area.

TABLE- 2

RESPONSE	NUMBER	PERCENTAGE
YES	77	77
NO	23	23
TOTAL	100	100

The above table- 2 depicts that majority of 77% subjects had lotus cultivation area in their location. And remaining 23% of subjects was not aware about the cultivation of lotus. Hence they did not know about the cultivation.

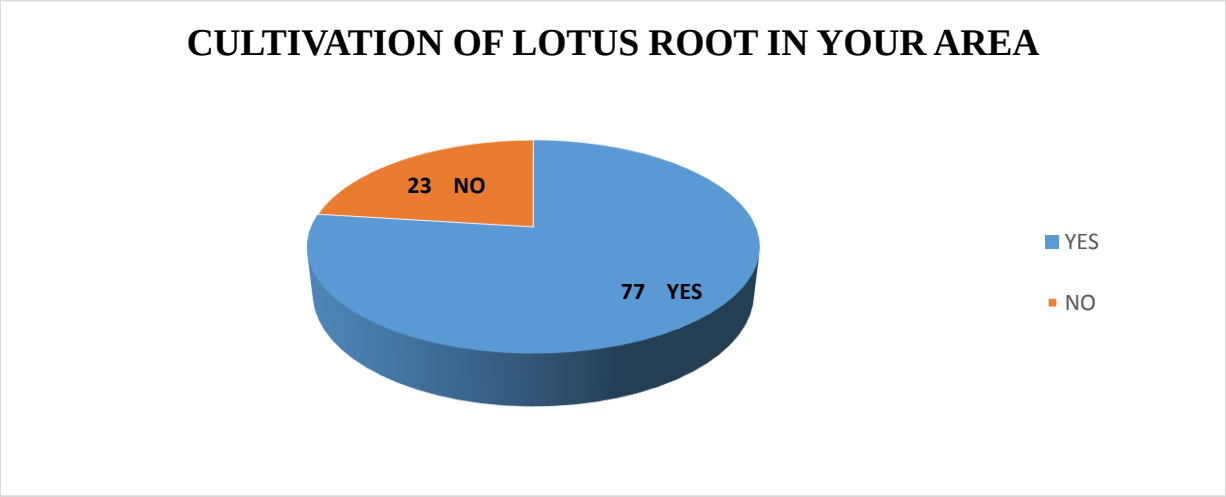


Fig 2

Cultivation of Lotus root in your area

4.3 KNOWLEDGE REGARDING PREPARATION OF LOTUS ROOT PRODUCTS

4.3.1 Knowledge regarding preparation of lotus root products

TABLE- 3

RESPONSE	NUMBER	PERCENTAGE
YES	61	61
NO	39	39
TOTAL	100	100

The above table- 3 depicts that about 61% of subjects had knowledge about preparing Lotus root products, and remaining only 39% of subjects were unaware of the preparation methods of Lotus root products.

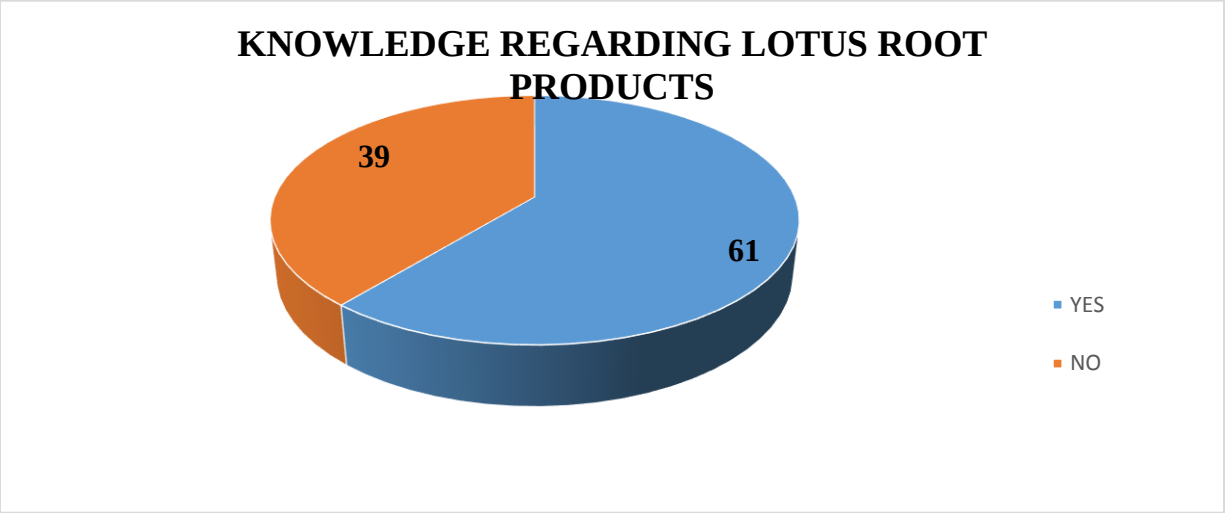


Fig 3

Knowledge regarding preparation of lotus root product

4.4 COLLECTION OF INFORMATION ABOUT AWARENESS OF LOTUS ROOT POWDER PRODUCTS

4.4.1 Consumption pattern of Lotus Root powder products

TABLE- 4

FOOD ITEM	**NUMBER**	**PERCENTAGE**
HEALTH MIX	**8**	**8**
NUTRI BAR	14	14
CAKE	17	17
COOKIES	61	61
TOTAL	100	100

Eating habits of selected subjects is given in table-4, were a majority of 61% of subjects preferred cookies, 17% preferred cake, and 14% preferred nutri bar, 8% preferred health mix . This helped me to development and formulate healthy food products using lotus root powder.

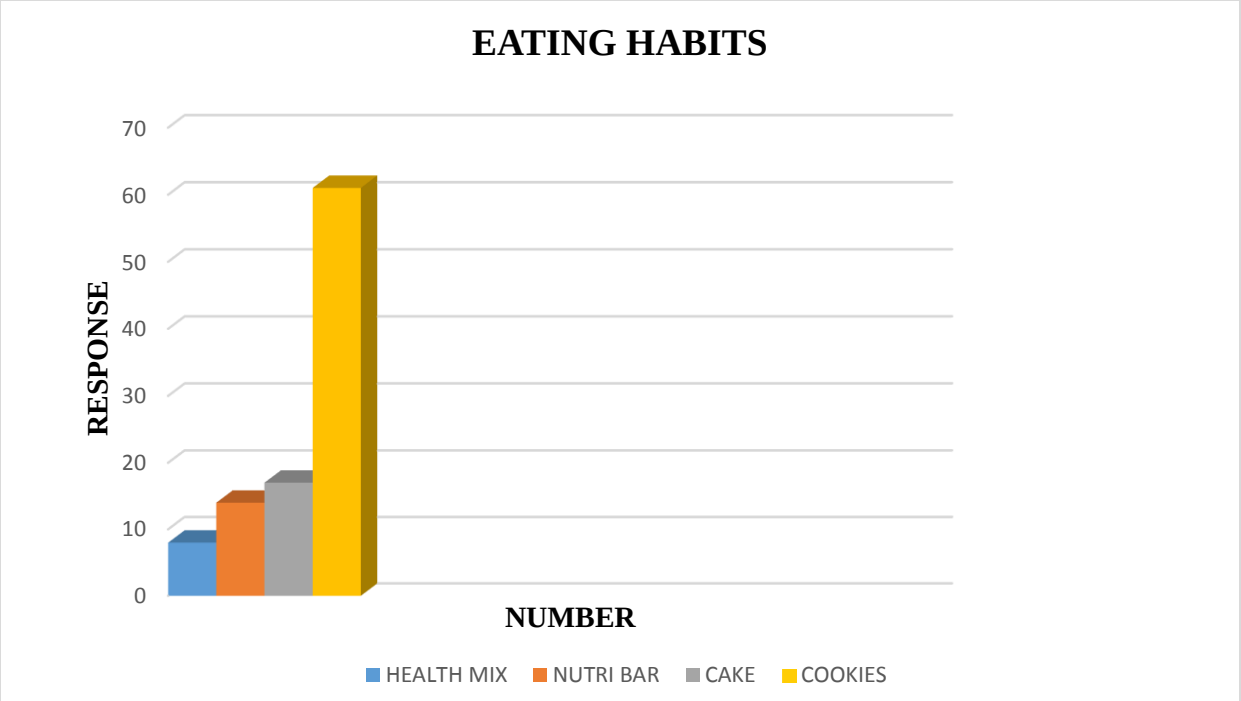


Fig 4

Consumption pattern of Lotus Root powder products

4.4.2 PERCENTAGE IN-COOPERATION OF LOTUS ROOT IN DIET

TABLE-5

RESPONSE	NUMBER	PERCENTAGE
Once in a week	14	14
Twice in a week	24	24
Daily	7	7
Monthly	55	55
TOTAL	100	100

The in-cooperation of Lotus root powder of the selected subjects were given in the table-5.A majority of 55% of subjects preferred monthly in-cooperation, 14% of subjects preferred once in a week, 24% of subject preferred twice in a week and only 7% of subject preferred daily in-cooperation in their diet.

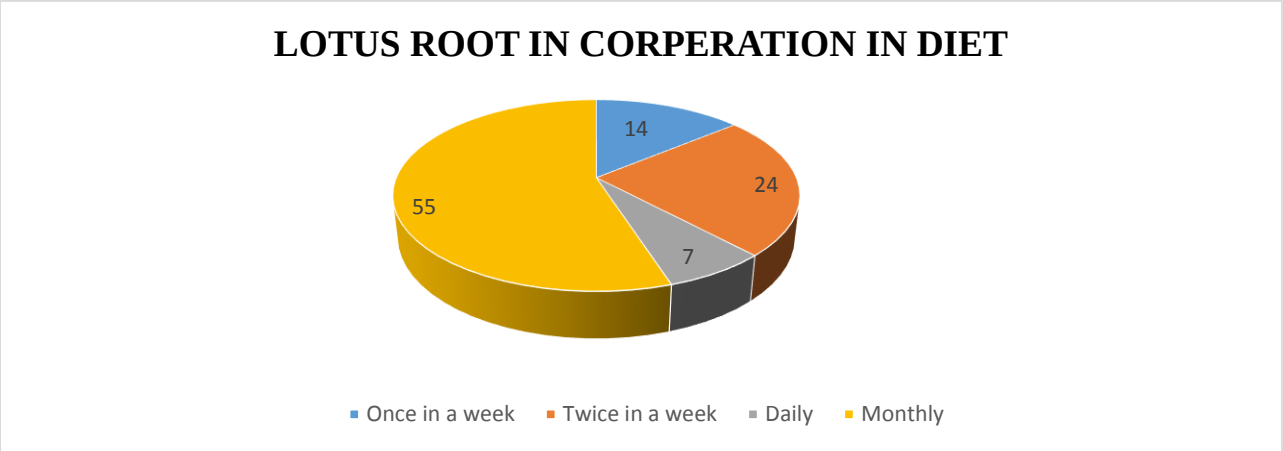


Fig 5

Percentage in-cooperation of lotus root in diet

4.4.3 AWARENESS ON COMMON USES OF LOTUS ROOT

4.4.3 Awareness on common uses of lotus root among the selected subjects

TABLE- 6

Type of consumption	**Number**	**Percentage**
Dried	23	23
Raw	23	23
Processed	42	42
Pickled	12	12
Total	100	100

The above table- 6 depicts that about 12% of subjects consumed lotus root in preserved form as pickled, 23% of subjects consumed in dried form, 23% of subjects preferred to have it in raw form and 42% of subjects preferred as processed form.

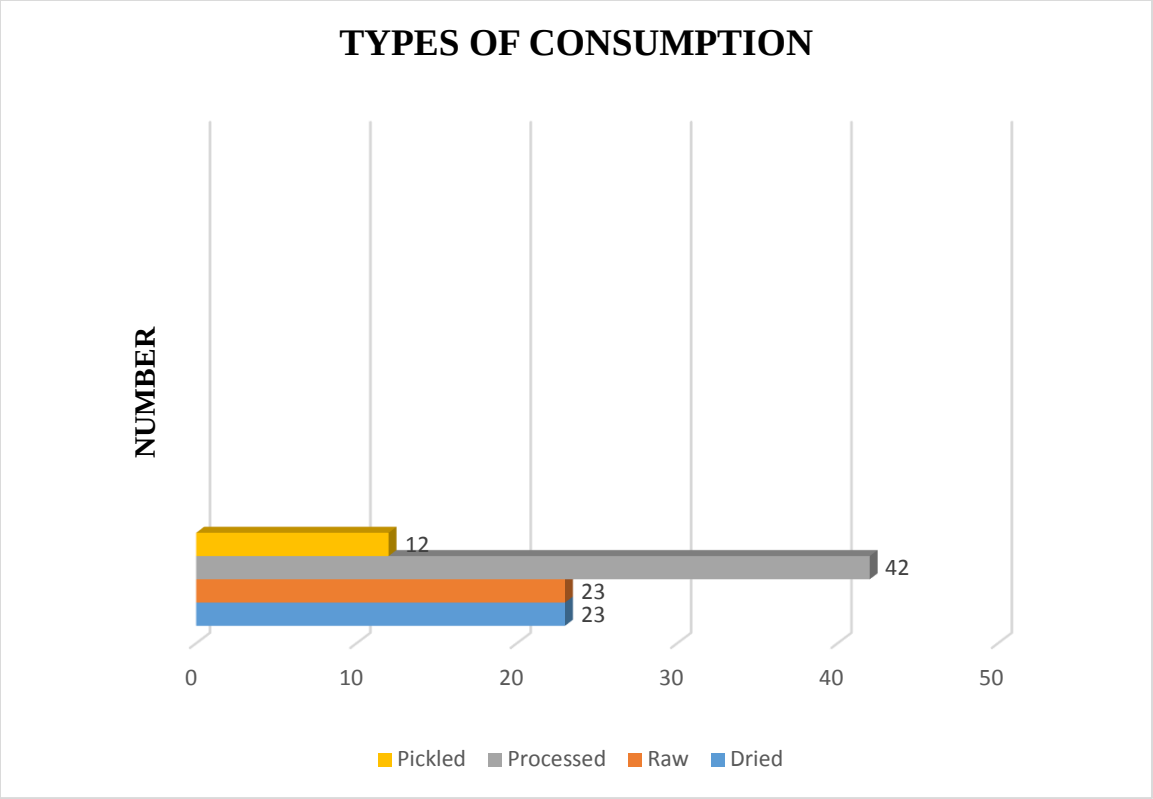


Fig 6

Awareness on common uses of lotus root among the selected subjects

4.4.4 HEALTH ISSUES AMONG THE SELECTED SUBJECTS

4.4.4 Health issues among the selected subjects

TABLE- 7

Health issues	**Number**	**Percentage**
Diabetics	9	9
Hypertension	9	9
Heart disease/ hyper lipidemia	0	0
Obesity	17	17
Anemia	20	20
None	45	45
Total	100	100

The health issues of selected subjects were depicted in table- 7 and also plotted in the graph. Majority 45 % of subjects did not have any health issues. About 17% of the subjects were obese, whereas 9% of subjects were diabetics and hypertension; and 20% of the subjects were prone to anemia.

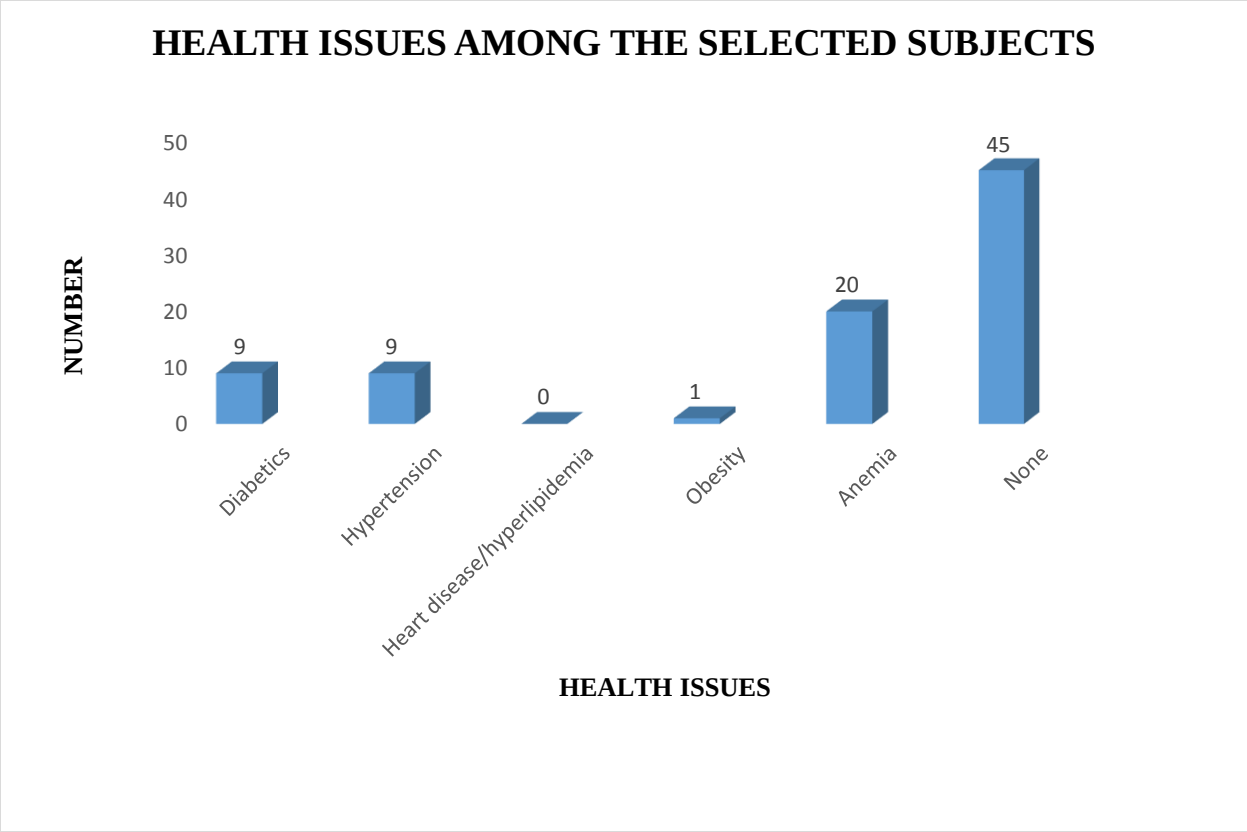


Fig 8

Health issues among the selected subjects

4.4.5 TYPE OF LOTUS ROOT PREFERRED BY THE SELECTED SUBJECTS

4.4.5 Type of lotus root preferred by the selected subjects

TABLE- 8

Type of fruit	**Number**	**Percentage**
Dry	42	42
Tender	30	30
Matured	28	28
Total	100	100

The type of Lotus root preferred by the selected subjects were depicted in the table- 8.Majority of 42% preferred dry root , 30% preferred tender root and the remaining 28% preferred matured root

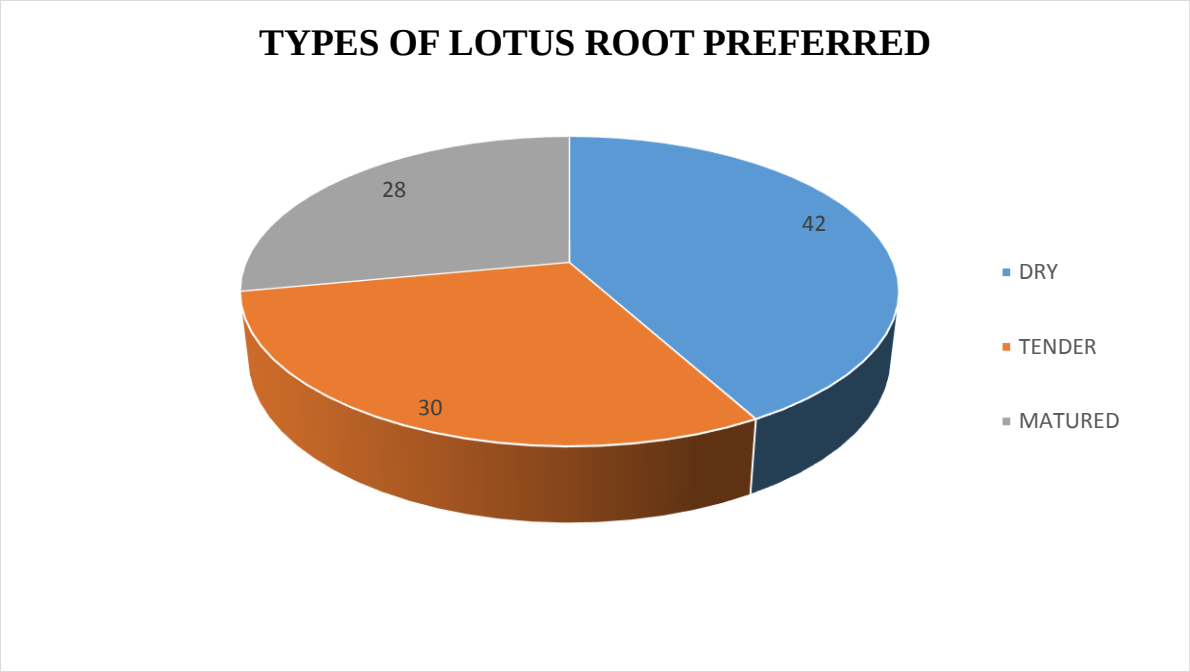


Fig 9

Type of lotus root preferred by the selected subjects

4.4.6 ALLERGIES TO LOTUS ROOT

4.4.6 Allergies to lotus root

TABLE- 9

Response	Number	Percentage
Yes	7	7
No	93	93
Total	100	100

The allergic condition to Lotus root of selected subjects were depicted in table 9. It was found that the 93% of the selected subjects are not allergic to Lotus root, were 7% of the selected subjects were allergic to Lotus root

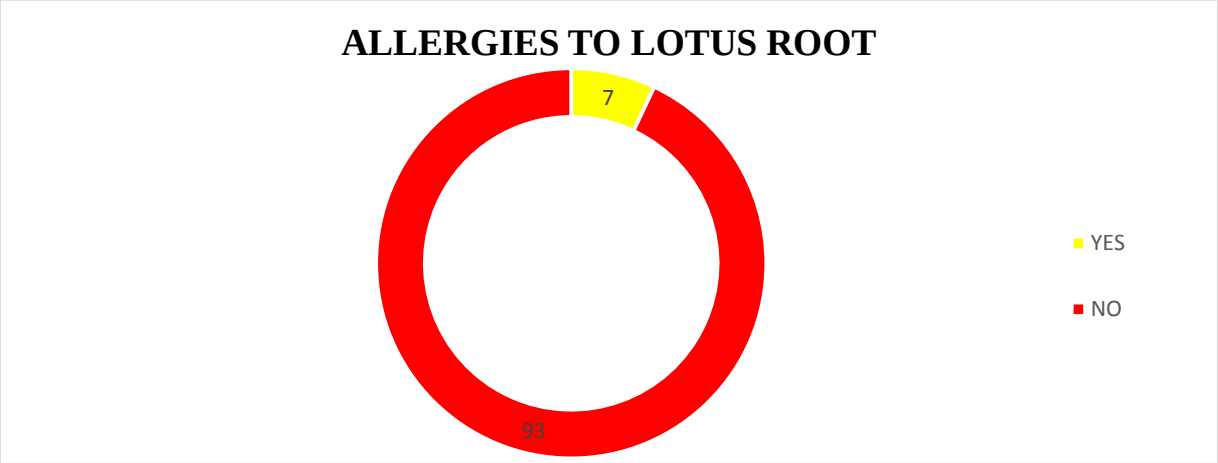


Fig 10

Allergies to lotus root

4.4.7 AWARENESS ON HEALTH BENEFITS OF LOTUS ROOT AMONG THE SELECTED SUBJECTS

4.4.7 Awareness on health benefits of lotus root among the selected subjects

TABLE- 10

RESPONSE	**NUMBER**	**PERCENTAGE**
YES	46	46
NO	54	54
TOTAL	100	100

The above table depicts that majority 46% of subjects were aware of health benefits of Lotus root and the remaining 54 % of subjects were not aware about it.

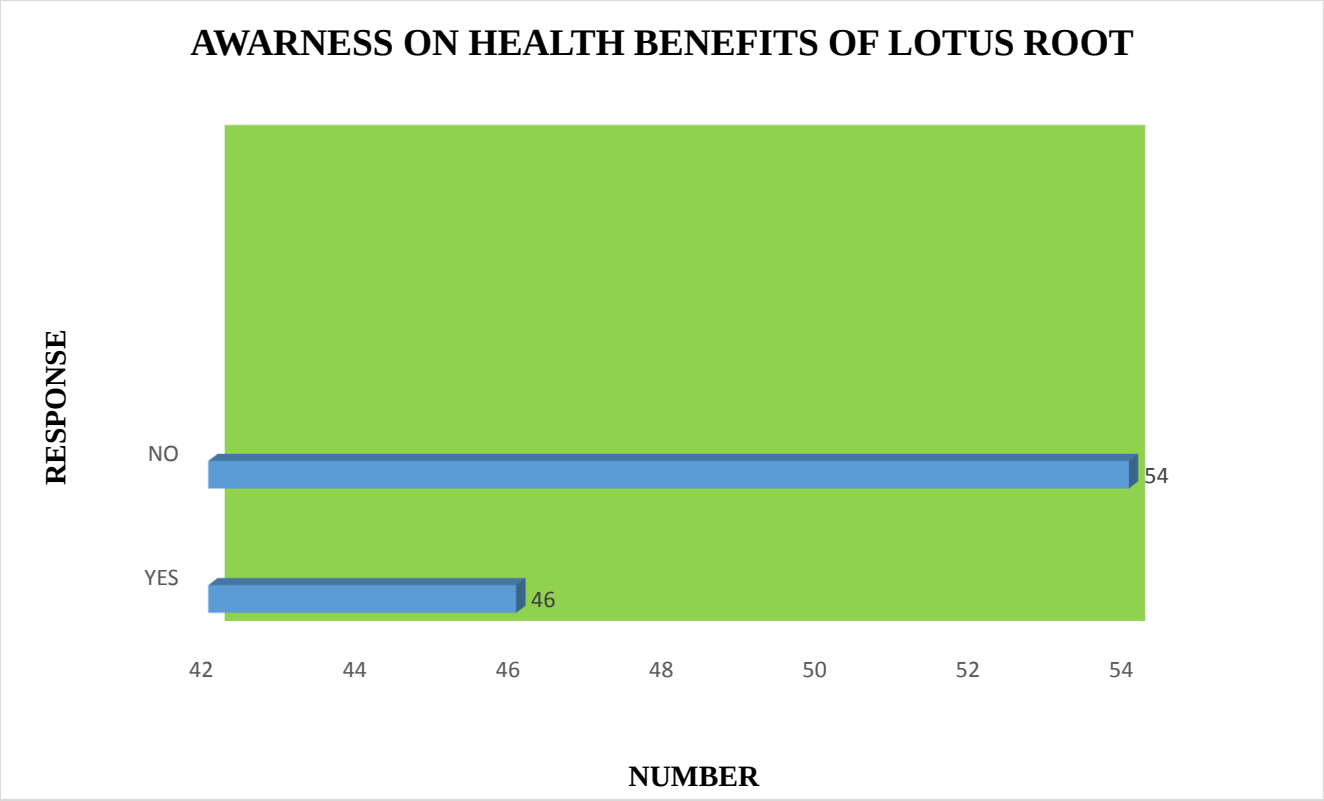


Fig 11

Awareness on health benefits of lotus root among the selected subjects

4.4.8 RESPONSE TO LIKES AND DISLIKES OF LOTUS ROOT BY SELECTED SUBJECTS

TABLE-11

RESPONSE	NUMBER	PERCENTAGE
YES	68	68
NO	32	32
TOTAL	100	100

The above table- 11 depicts that majority of 68% of the subjects liked Lotus root were the remaining 32% of subjects had disliking towards Lotus root

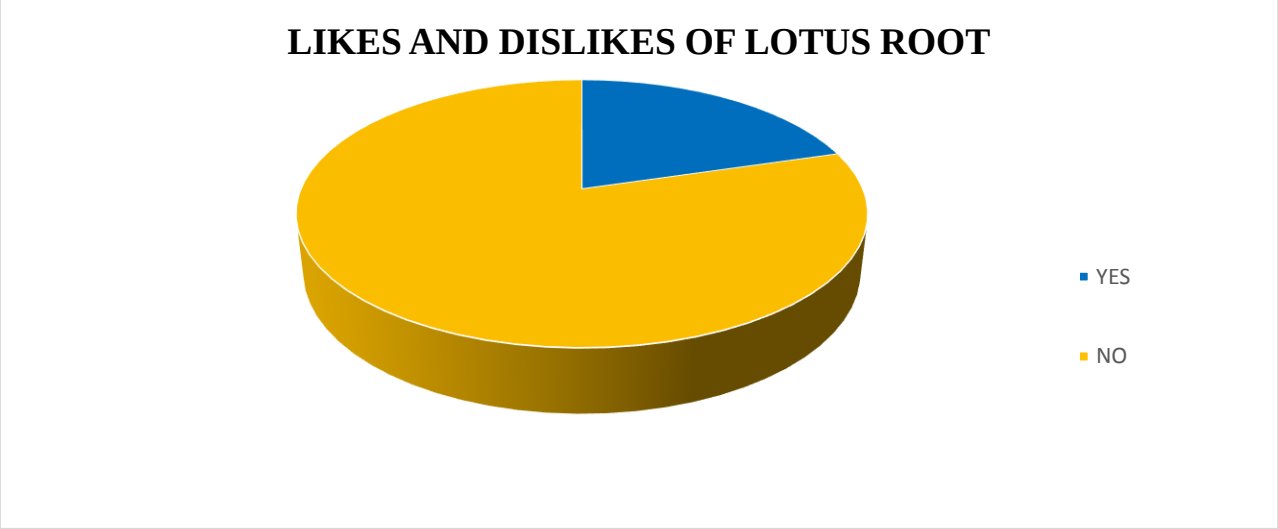


Fig 12

Response to likes and dislikes of lotus root by selected subjects

4.4.8 WILLINGNESS FOR PURCHASE OF LOTUS ROOT PRODUCTS

4.4.8 Willingness for purchase of lotus root products

TABLE- 12

RESPONSE	NUMBER	PERCENTAGE
YES	53	53
NO	47	47
TOTAL	100	100

From the collected data it is revealed that 53% of adolescent girls were willing to purchase lotus root food products if made available in the market

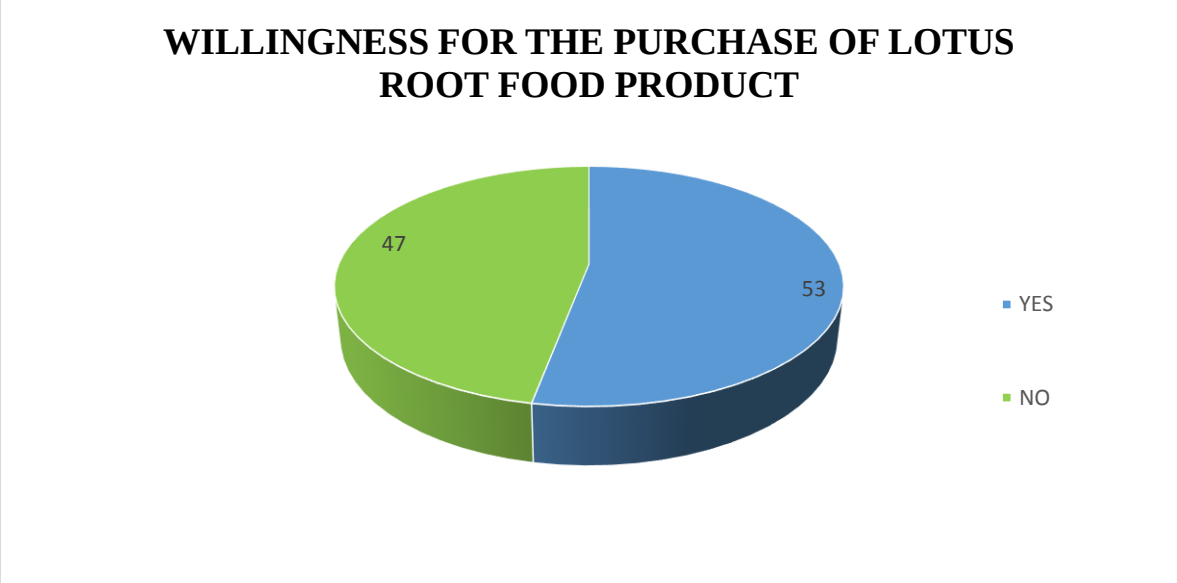


Fig 13

Willingness for purchase of lotus root products

4.5 OVERALL SENSORY EVALUATION OF LOTUS ROOT CAKE DEVELOPED

4.5.1 AVERAGE MEAN SENSORY SCORES OF THE DEVELOPED LOTUS ROOT CAKE

TABLE-13

FORMULA VARIATION IN LOTUS ROOT CAKE	APPEARANCE	COLOUR	TASTE	TEXTURE	OVERALL ACCEPTABILITY
LRCA 20:75	4.83	4.58	4.29	4.33	4.45
LRCB 30:75	6.12	5.29	4.91	5.66	5.79
LRCC 50:75	7.83	8.12	7.95	7.87	8.04

***LOTUS ROOT POWDER: WHEAT FLOUR** ***LRC – LOTUS ROOT CAKE**

The organoleptic evaluation by 24 selected panel member along with graphical representation are depicted in TABLE-1. Among the 3 different sample variation of cake prepared LRCA – 20:75, LRCB – 30: 75, LRCC – 50: 75, (Lotus root cake) LRCC with 50 :75 ratio squash was the most acceptable for all the twenty four panel members. It possessed highest scores in all the organoleptic

parameter. Therefore this sample ratio of lotus root cake was taken for further standardization and processing of the study.

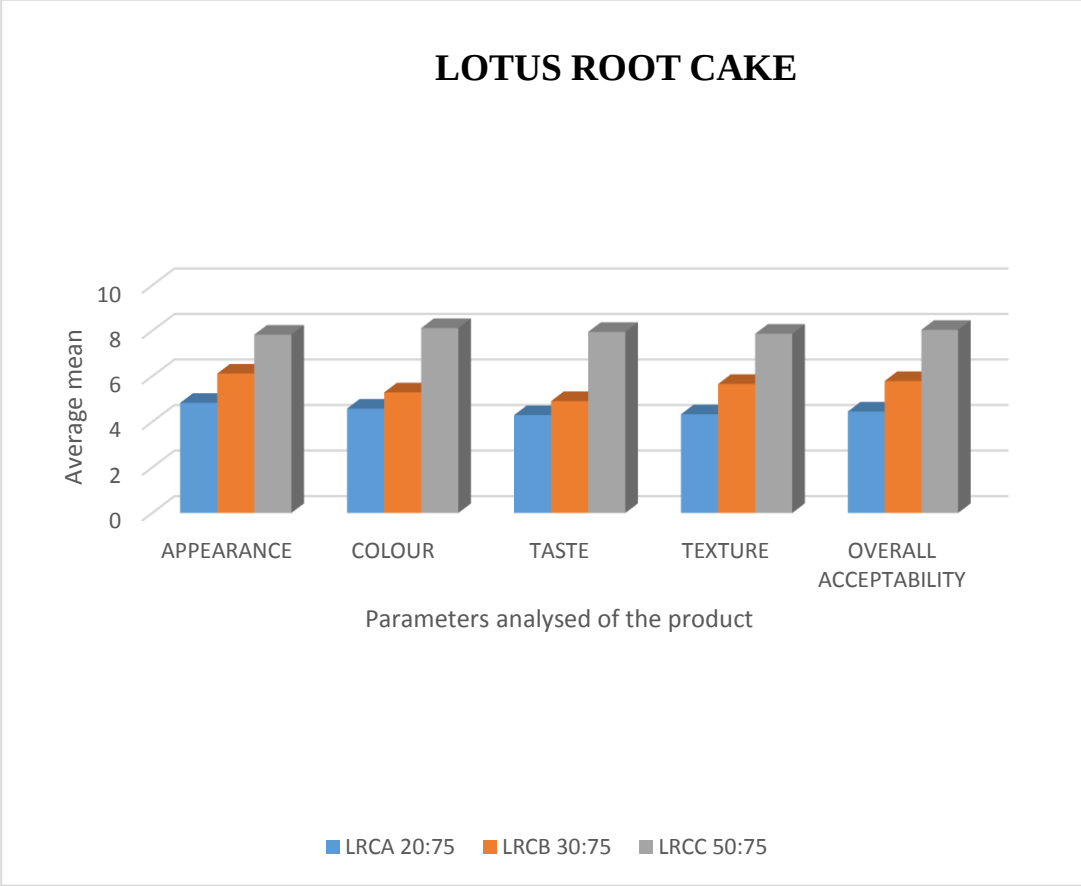


Fig. 13

Average mean sensory scores of the developed lotus root cake

4.5.2 AVERAGE MEAN SENSORY SCORES OF THE DEVELOPED LOTUS ROOT COOKIES

TABLE-14

FORMULA VARIATION IN HALWA	APPEARANCE	COLOUR	TASTE	TEXTURE	OVERALL ACCEPTABILTY
LRCA 20:75	**3.83**	**4.12**	**4.16**	**4.16**	**4**
LRCB 30:75	**8.41**	**7.70**	**8.16**	**8.25**	**8.08**
LRCC 50:75	**3.91**	**4.12**	**4.08**	**3.87**	**4.08**

*** LOTUS ROOT POWDER: WHEAT FLOUR** **LRC – LOTUS ROOT COOKIES**

The organoleptic evaluation by 24 selected panel members are depicted in (TABLE 7) along with graphical representation. Among 3 sample variations kept for evaluation, Lotus root cookies B 30:75 ratio is the most acceptable among the 3 different variations among all the twenty four panel members. It possessed highest score in all the organoleptic parameters. There for this sample ratio of Lotus root cookies was taken for further standardisation and processing of the study.

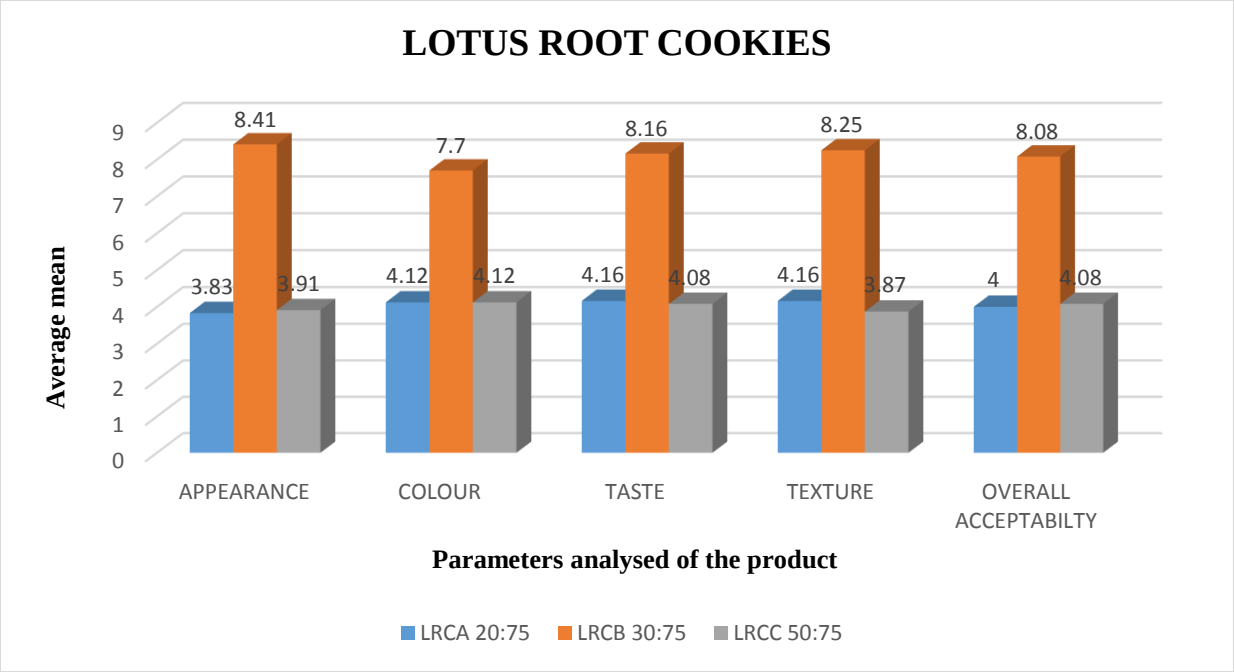


Fig- 14

Average mean sensory score of the developed lotus root cookies

4.5.3 AVERAGE MEAN SENSORY SCORES OF THE DEVELOPED LOTUS ROOT NUTRI BAR

TABLE-15

FORMULA VARIATION IN PAPAD	APPEARANCE	COLOUR	TASTE	TEXTURE	OVERALL ACCEPTABILTY
LRNA 20:75	3.83	3.83	4.04	3.58	3.95
LRNB 30:75	7.70	8.45	8.37	7.91	8.41
LRNC 50:75	3.37	3.66	3.54	3.25	4.04

***LOTUS ROOT POWDER: OATS LRN: LOTUS ROOT NUTRI BAR**

The organoleptic evaluation by 24 selected panel members are depicted in (TABLE 8) along with graphical representation. Among 3 sample variations kept for evaluation, Lotus root nutri bar B 30:75 ratio is the most acceptable among the 3 different variations for all the twenty four panel members. It possessed highest score in all the organoleptic parameters. There for this sample ratio of lotus root nutri bar was taken for further standardisation and processing of the study.

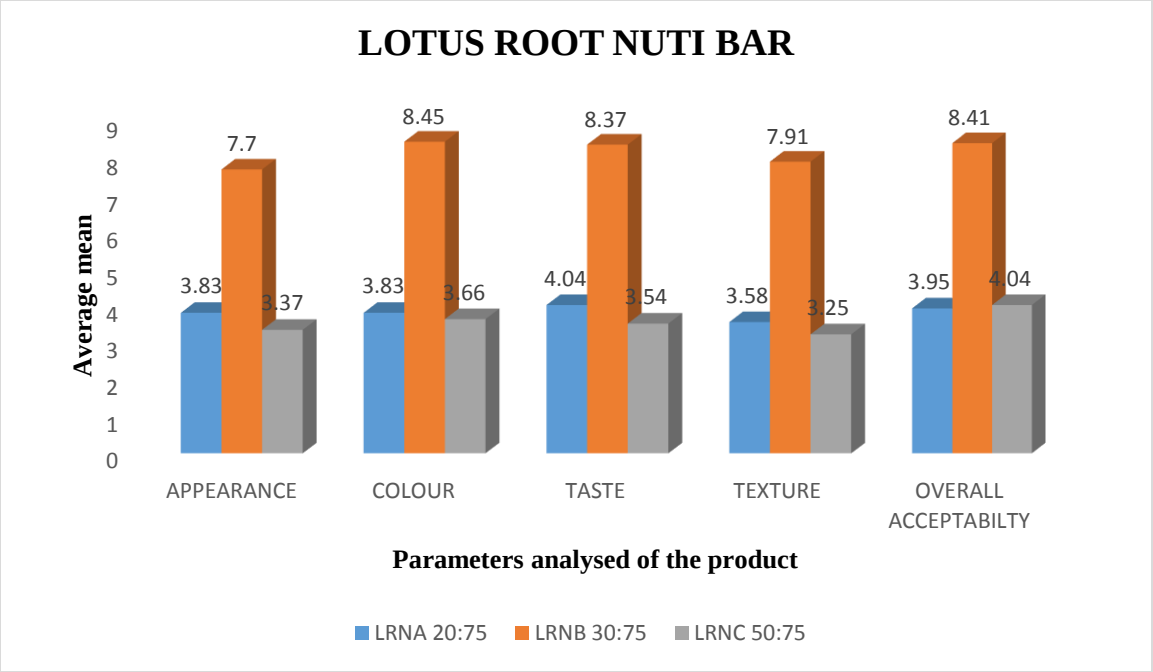


Fig-15

Average mean sensory score of the developed lotus root nutri bar

4.5.4 AVERAGE MEAN SENSORY SCORES OF THE DEVELOPED LOTUS ROOT HEALTH MIX

TABLE- 16

FORMULA VARIATION IN CHAMMANTHI	APPEARANCE	COLOUR	TASTE	TEXTURE	OVERALL ACCEPTABILITY
LRHA 20:75	7.83	8.12	7.87	7.95	8.29
LRHB 30:75	3.20	3.08	2.91	3	3.08
LRHC 50:75	3.87	3.70	3.08	3.04	3.08

***LOTUS ROOT POWDER: ROASTED GRAM *LRH: LOTUS ROOT HEALTH MIX**

The organoleptic evaluation by 24 selected panel members are depicted in (TABLE-9) along with graphical representation.

Among 3 sample variations kept for evaluation Lotus root health mix A 20:75 ratio is the most acceptable among the 3 different variations for all the twenty four panel members. It possessed highest score in the all the organoleptic parameters. There for this sample ratio of lotus root health mix was taken for further standardisation and processing of the study.

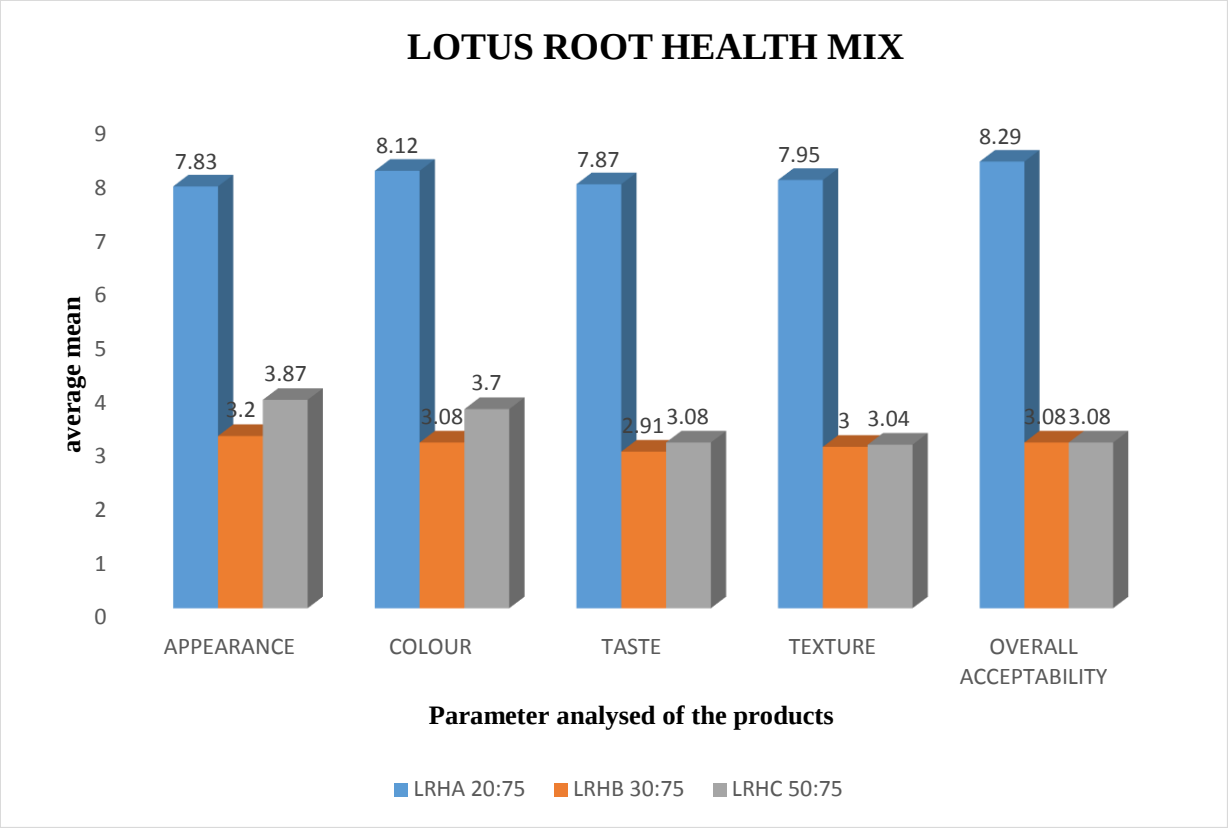


Fig-16

Average mean sensory score of the developed lotus root health mix

4. 6 FRIEDMAN'S TEST FOR ACCEPTABILITY OF LOTUS ROOT CAKE

4.6.1 FRIEDMAN'S TEST FOR OVERALL ACCEPTABILITY OF LOTUS ROOT CAKE

TABLE- 18

Number of panel members (N)	RANK FOR DIFFERENT RATIO		
	Lotus root cake A(20:75)	Lotus root cake B(30:75)	Lotus root cake C(50:75)
1	1	2	3
2	1	2	3
3	1. 5	1. 5	3
4	1. 5	1. 5	3
5	1	2	3
6	1. 5	1. 5	3
7	1	2	3
8	1	2	3
9	1	2	3
10	2	1	3
11	1	2	3
12	1. 5	1. 5	3

13	**1**	**2**	**3**
14	**1**	**2**	**3**
15	**1**	**2**	**3**
16	**2**	**1**	**3**
17	**1**	**2**	**3**
18	**1**	**2**	**3**
19	**1**	**2. 5**	**2. 5**
20	**1**	**2**	**3**
21	**1**	**2**	**3**
22	**1**	**1**	**3**
23	**2**	**2**	**3**
24	**1**	**2**	**3**
TOTAL	**29**	**43. 5**	**71.5**

Calculated FM Test Statistic= 38.89

FM critical Value from table (Friedman's ANOVA by ranks critical value table) = 7.14

The null hypothesis for the test was that the samples differ from each other in their overall acceptability. From the above result it is clear that the calculated FM statistics is greater than the FM critical value. So rejected the null hypothesis.

4.6.2 FRIEDMAN'S TEST FOR OVERALL ACCEPTABILITY OF LOTUS ROOT COOKIES

TABLE- 19

Number of panel members (N)	RANK FOR DIFFERENT RATIO		
	Lotus root cookies A(20:75)	Lotus root cookies B(30:75)	Lotus root cookies C(50:75)
1	1	2	3
2	2	1	3
3	1. 5	1. 5	3
4	2	1	3
5	1	2	3
6	1. 5	1. 5	3
7	1	2	3
8	2	1	3
9	1. 5	1. 5	3
10	1	2	3
11	1	2. 5	2. 5
12	1	2	3
13	2	1	3

14	**2**	**1**	**3**
15	**1**	**2**	**3**
16	**1. 5**	**1. 5**	**3**
17	**1. 5**	**1. 5**	**3**
18	**1**	**2**	**3**
19	**2**	**1**	**3**
20	**1. 5**	**1. 5**	**3**
21	**2**	**1**	**3**
22	**2**	**1**	**3**
23	**2**	**1**	**3**
24	**1. 5**	**1. 5**	**3**
TOTAL	**36.5**	**36**	**71. 5**

Calculated FM Test Statistic = 34. 52

FM critical value from table (Friedman's ANOVA by ranks critical value table) = 7.14

The null hypothesis for the test was that the samples differ from each other in their overall acceptability. From the above result it is clear that the calculated FM statistics is greater than the FM critical value. So reject the null hypothesis.

4.6.3 FRIEDMAN'S TEST FOR OVERALL ACCEPTABILITY FOR LOTUS ROOT NUTRI BAR

TABLE- 20

Number of panel members (N)	RANK FOR DIFFERENT RATIO		
	Lotus root nutri bar A(20:75)	Lotus root nutri bar B(30:75)	Lotus root nutri bar C(50:75)
1	1. 5	3	1. 5
2	1	3	2
3	2	3	1
4	1. 5	3	1. 5
5	2	3	1
6	2	3	1
7	2	3	1
8	1	3	2
9	1	3	2
10	1. 5	3	1. 5
11	1. 5	3	1. 5
12	2	3	1
13	1. 5	3	1. 5

14	**2**	**3**	**1**
15	**1. 5**	**3**	**1. 5**
16	**2**	**3**	**1**
17	**1**	**3**	**2**
18	**1. 5**	**3**	**1. 5**
19	**1**	**3**	**2**
20	**1. 5**	**3**	**1. 5**
21	**1**	**3**	**2**
22	**1**	**3**	**2**
23	**1**	**3**	**2**
24	**1**	**3**	**2**
TOTAL	**35**	**72**	**37**

Calculated FM Test Statistic= 36.08

FM critical Value from table (Friedman's ANOVA by ranks critical value table) =7.14

The null hypothesis for the test was that the samples differ from each other in their overall acceptability. From the above result it is clear that the calculated FM statistics is greater than the FM critical value. So rejected the null hypothesis.

4.6.4 FRIEDMAN'S TEST FOR OVERALL ACCEPTABILITY FOR LOTUS ROOT HEALTH MIX

TABLE- 21

Number of panel members (N)	RANK FOR DIFFERENT RATIO		
	Lotus root health mix A(50:25)	Lotus root health mix B(25:50)	Lotus root health mix C(25:50)
1	3	1. 5	1.5
2	3	2	1
3	3	2	1
4	3	1. 5	1. 5
5	3	1	2
6	3	1	2
7	3	1. 5	1. 5
8	3	1	2
9	3	1	2
10	3	2	1
11	3	1. 5	1. 5
12	3	1	2
13	3	1. 5	1. 5

14	**3**	**2**	**1**
15	**3**	**1**	**2**
16	**3**	**2**	**1**
17	**3**	**1. 5**	**1. 5**
18	**3**	**2**	**1**
19	**3**	**2**	**1**
20	**3**	**2**	**1**
21	**3**	**1**	**2**
22	**3**	**2**	**1**
23	**3**	**1**	**2**
24	**3**	**1**	**2**
TOTAL	**72**	**36**	**36**

Calculated FM Test Statistic= 36

FM critical Value from table (Friedman's ANOVA by ranks critical value table) = 7.14

The null hypothesis for the test was that the samples differ from each other in their overall acceptability. From the above result it is clear that the calculated FM statistics is greater than the FM critical value. So rejected the null hypothesis.

TABLE. 22 Nutrient composition of Lotus root incorporated food products (per 100 g)

Product name	Dietary fiber (g)	Calcium(mg)	Iron(mg)
Lotus root cake	9.8	34.71	3.3
Lotus root cookies	8.78	30.1	3.8
Lotus root nutri bar	14.7	38.08	4.07
Lotus root health mix	10.07	33.06	4.31

As per TABLE 23, the product with highest Calcium content was Lotus root nuti bar (38.08 mg). The product which showed lowest Calcium was Lotus root cookies (30.1mg) .The item also showed lowest amount of dietary fiber (8.78g) compared to other Lotus root products.

The iron content of the lotus root health mix was the highest (4.31mg) as it was roasted in a iron Kadai whereas Lotus root cake showed only 3.3mg of iron in it. Among four Lotus root products developed, the calcium rich product was found to be Lotus root nutri bar which contained 38.08mg in it.The lotus root products also checked the carbohydrate, protein value which have the highest.

Lotus root is dietary fiber, iron and calcium rich fruit. Hence all the products prepared from Lotus root were found to be rich in dietary fiber, iron and calcium.

TABLE. 23 Shelf life of Lotus root in-cooperated products (room temperature)

Product name	Storage capacity/g	Variations		
		A	B	C
Lotus root cake	100	1 week	2 ½ weeks	1 month
Lotus root cookies	100	2 week	1 month	2 months
Lotus root nutri bar	100	1 month	1 ½ months	3 months
Lotus root health mix	100	3 weeks	2 months	3 month

The shelf life qualities of developed products were assessed for a period of 3 months at room Temperature. The findings are given in TABLE 24. Three variations of all the Lotus root in-corporate products (containing 100g products each) were kept for a period of 3 months and examined visually on a daily basis for microbial infestation and noted down the period in which first microbial infiltration was seen. That period was taken as the shelf life of the product under normal room temperature. The products were evaluated organoleptically at the end of each month to find out the changes in their sensory qualities.

When a food is considered unsuitable for consumption, it is said to have reached the end of shelf life. Sugar, salt and oil were used as the major preservatives in the preparation of the products which determined the shelf life of each product. The products like Lotus root nutri bar (3 months), and Lotus root health mix (3 months) got the highest shelf life, since these two products contained

higher amounts of sugar and powder along with small amounts of salt respectively. The next place was occupied by Lotus root cookies (2 months). High amount of oil and common preservatives like sugar and salt contributed to the longer shelf life of these products. The product Lotus root cake had shelf life of 1 month.

TABLE. 24 Evaluation of time taken for the preparation of Lotus root incorporated products

Product name	Amount(g)	Time analysis		
		Preliminary Preparation time(minutes/ day)	Cooking time(minutes)	Total time (minutes)
Lotus root cake	100	45	35	1 hour and 20 minutes
Lotus root cookies	100	45	30	1 hour and 15 minutes
Lotus root nutri bar	100	20	30	50
Lotus root health mix	100	30	10	40

TABLE 24 indicates the time taken for preparing 100g of each lotus root incorporated products. The data depicted in the TABLE 24 revealed that the time taken for cooking lotus root cake and cookies was highest because of the longer preliminary preparations and cooking time (1 hour 20 minutes).

Least time for production i.e., 25 minutes was taken for the preparation of products like lotus root health mix. This was because all the ingredients were blended or mixed in raw forms to prepare desired product.

SUMMARY AND CONCLUSION

CHAPTER-5

SUMMARY AND CONCLUSION

Every part of lotus root (Nelumbo nucifera) is said to help in the treatment of diseases .In order to meet the objectives of the study, four products were prepared by incorporating Lotus root. The products developed are Lotus root cake, Lotus root cookies, Lotus root nutria bar and Lotus root health mix. The products were prepared in three variations namely variation A, variation B and variation C which contained various proportions of Lotus root, incorporated in 20 per cent, 30 per cent and 50 percent in them along with other ingredients for achieving enhanced quality and adequate quantity of the nutrients in the products.

A score card was prepared to select the judging panel of twenty four members. Another nine point score card was prepared to evaluate the sensory qualities of the prepared products. Among the prepared variations, variation C of Lotus root cake(8.04), variation B of Lotus root cookies (8.08), variation B of Lotus root nutria bar(8.41), variation A of Lotus root health mix (8.29), were selected as the best variations of each developed Lotus root incorporated products.

The prepared products contained, calories within range of 3.30- 70.76 K cal, carbohydrates within the range of 66 .34-85.49 g, protein within the range of 4.96-10.40g and fat within a range of 0.03-22.13g per 100g of each product.. They also supplied adequate amount of calcium (30.43-38.08mg) and iron (3.3- 4.31 mg). Lotus root incorporated products were found to be rich in nutrients especially carbohydrates, calcium and dietary fiber, while it supplied less amount of

calorie, and fat. The developed products were analyzed for their shelf life qualities for a period of 3 months at room temperature.

Among the developed products, two of the best product variation with highest overall acceptability scores namely Lotus root cookies and lotus root nutria bar were popularized among adolescents of thrissur. For the process of popularization, charts and brochures were prepared. The responses given by the adolescent girls showed that they had the interest to cultivate lotus root and also to incorporate lotus root in their daily diet.

The rhizome is also used for arresting bleeding, dissipating blood stasis, improving appetite, haematemesis and hemoptysis. Powdered rhizome is prescribed as a demulcent for haemarrhoids and is beneficial in dysentery and chronic dyspepsia.External application in the form of a paste is useful in scabies and ring worm. The rhizome yields a nutritious arrowroot that is used for diarrhoea, dysentery and dyspepsia in children. The production and consumption of lotus root incorporated recipes, will help to prevent these types of diseases to a remarkable extent. Most of the people are not aware about the nutritional and medicinal importance oflotus root. Lotus root incorporated products are not readily available in markets. Hence the current study which highlights the incorporation of lotus root into common foods is beneficial, because of its convenience in cultivation, nutritional benefits, and medicinal uses and less expense.

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APPENDIX

APPENDIX 1

QUESTIONNAIRE TO ELICIT THE FOOD HABITS OF ADOLESCENT GIRLS IN THRISSUR

1. PERSONAL INFORMATION

Name:

Age:

Address:

Phone number: Height……. Weight…….

Occupation:

2. Does your area consist of lotus cultivation?

Yes ☐ No ☐

3. Do you know how to prepare lotus root products?

Yes ☐ No ☐

4. Which are the lotus root products that you have consumed so far?

Health mix ☐ cakes ☐ cookies ☐ nutri bar ☐

5. How often do you in-cooperate lotus root in your diet?

Once in a week ☐ twice in week ☐ daily ☐ Monthly ☐

6. Do you know the health benefit of lotus root?

Yes ☐ No ☐

7. Are you allergic to lotus root?

Yes ☐ No ☐

8. Do you know the nutritional importance of lotus root?

Yes ☐ No ☐

If yes, please specify the nutrients

9. Do you like lotus root?

Yes ☐ No ☐

If yes, specify……

10. For what reason do you like lotus root?

Taste ☐ Color ☐ Other ☐

Other please specify……

11. In what form do you consume lotus root?

Dried ☐ Raw ☐ Processed ☐ Pickled ☐

12. Do you know the anti-nutritional factors present in lotus root?

Yes ☐ No ☐

If yes, specify……

13. Do you have any health problems?

☐ Diabetic

☐ Hypertension

☐ Heart disease/hyperlipidemia

☐ Obesity

☐ Aneamia

☐ None

14. Do you believe that consuming lotus root improve hypertension or aneamia?

Yes ☐ No ☐

15. Do you know the toxic effect of consuming excess of lotus root?

Yes ☐ No ☐

16. What are the factors that indicate bilimbi fruit is of good quality and taste?

Type ☐ Origin ☐ Color ☐ Freshness ☐

Size ☐ Firmness ☐ Smell ☐ Other ☐

Other (please specify)……

17. What is your perception of the quality of lotus root powder available to you?

Very good quality ☐ Good quality ☐

Average quality ☐ Poor quality ☐

18. What type of lotus root do you prefer?

Tender ☐ Matured ☐ Dry ☐

19. Why would you consider including organic lotus root?

Healthier ☐ Pesticide/chemical free ☐

Sustainable ☐ Tastier ☐ Other ☐

Other please specify

20. Do you know the shelf-life of lotus root at room temperature?

One or two days ☐ One week ☐

One month ☐ or more ☐

21. Do you know the shelf-life of lotus root during refrigeration?

One or two days ☐ One week ☐

One month ☐ or more ☐

22. What could be a reason for you to try, a new recipe of lotus root?

☐ Better quality perception

☐ Less time for preparation

☐ Bored from the earlier recipe

☐ Other

Other, please specify……

23. If recommended will you prefer lotus root?

Yes ☐ No ☐

APPENDIX-2

SENSORY EVALUATION CARD

NAME OF EVALUATION CARD:

DATE :

PRODUCT NAME :

INSTRUCTION TO FOLLOW

Please rinse your mouth with water before starting.

You may rinse your mouth again at any time during testing if you need to.

Please taste the three sample in order presented from left to right.

You may re-taste the samples once you have tried all of them score the sample.

Within the possible scores with a total score of 100.

9 points hedonic score rating card

Sample No.	**Appearance**	**Color**	**Taste**	**Texture**	**Overall acceptability**
1					
2					
3					

Please evaluate the sample by ticking on any of the number according to your perception

9 = Like extremely

8 = Like very much

7 = Like moderately

6 = Like slightly

5 = Neither like or dislike

4 = Dislike slightly

3 =Dislike moderately

2 = Dislike very much

1 = Dislike extremely

SIGNATURE OF THE PARTICIPANT

THANK YOU FOR PARTICIPATION

APPENDIX- 3

NUTRITIVE VALUE OF LOTUS ROOT FOOD PRODUCTS CALCULATION METHOD

CALCULATION METHOD

1. Energy

Conversion of energy in kilo joule to kilo calories

1 kcal = 4.184 KJ

= n/Kcal

= n Kcal

Therefore energy in kcal per 100 gm = X

Energy = X/100 x n

= n kcal

2. Protein in 100 gm = X

There total protein = X/100 x n

= n gm protein

3. Fat in 100gm = X

   There for total fat = X/100 x n

   = n gm fat

4. Carbohydrate in 100 gm = X/100 x n

   = n gm carbohydrate

APPENDIX – 4

DETERMINATION OF CALCIUM

Objective:

To determine the calcium present in the lotus root food products.

Applications and limitations:

This method is used to find the calcium content of milk, the hardness of water and the amount of calcium and calcium carbonate in various solid materials. It is a very established, reliable and accurate method but it take time to complete as done manually

Reagents:

NaOH-1 N, Murexide solution (ammonium purpurdate) -0.100mg of murexide with 10g of solid sodium chloride and grinding the mixture to 300-425 microns, Standard EDTA solution =0.01N

Procedure:

• Weigh accurately 5-10g of the material in previously weighed crucible

• Dry for 2 hours in an air oven maintained at 105±2° C and ignite the divided material in the dish with the flame of a burner for about 1 hour

• Complete the ignition by keeping in a muffle furnace at 600±20°C until grey ash results

• Cool in a desiccator and weigh

• Repeat the process of heating for 30 minutes, cooling and weighing till the difference in mass between two successive weighing is less than 1mg

• This ash is then dissolved in minimum amount of concentrated HCL and made upto 100ml using distilled water.

• Take 50 ml of this sample. Add 1N NaOH solution,a volume sufficient to produce a PH of 12-13

• Add 2-3 drops of the murexide indicator. Titrate against EDTA with continues stirring.

• The end point is indicated by colour change from pink to purple

Calculation

Calcium= (Titrate value*normality of EDTA*40.08*1000*dilution)/volume taken for test.

ESTIMATION OF IRON

Objective:

To determine the Iron present in the lotus root food products.

Applications and limitations:

This method is applicable to determine Iron by dry ashing and Flame Atomic Absorption Spectrometry

Apparatus and reagents:

Air oven, Muffle furnace, Desiccator, Spectrophotometer, Concentrated HCL, Hydroxylamine hydrochloride, Ammonium acetate buffer, 1, 10 Phenanthrolin solution

Procedure:

• Weigh accurately 5-10g of the material in previously weighed crucible

• Dry for 2 hours in an air oven maintained at 105±2° C and ignite the divided material in the dish with the flame of a burner for about 1 hour

• Complete the ignition by keeping in a muffle furnace at 600±20°C until grey ash results

• Cool in a desiccator and weigh

• Repeat the process of heating for 30 minutes, cooling and weighing till the difference in mass between two successive weighing is less than 1mg

• This ash is then dissolved in minimum amount of concentrated HCL and make up to 100ml using distilled water

• To 100ml of this sample and 50ml of blank, add 1ml hydroxylamine hydrochloride and add 0.5ml con .HCL.

• Then boil the contents to almost 20ml the volume for dissolution of all ions.

• Cool to room temperature. Add 10ml of ammonium acetate buffer and 10ml of 1, 10 Phenanthrolin solution and mix well

• Dilute to 100ml and place each standard solution and food solution into a separate cuvette.

• Measure and record the absorbance of each solution at 510nm using spectrophotometer

• Prepare a standard curve (Beer's Law) of the standard concentrations vs. absorbance.

Calculation:

The amount of Iron present in the sample can be calculated from the standard graph in mg/dl

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APPENDIX – 5

TOOLS DEVELOPED TO CREATE AWARENESS AMONG THE PARTICIPANTS

1. POWERPOINT

HEALTH BENEFITS

The root has many health benefits due its property like:

- Diuretic,
- Psychopharmacological,
- Anti-diabetic, anti-obesity,
- Hypoglycemic, antipyretic
- Antioxidant activities and anti-inflammatory
- A number of pharmacological activities
- Promoting compounds such as alkaloids, lipids, flavonols, carotenes, aporphine, nuciferine, phospholipids, flavonoids, xanthophylls, and minerals

NUTRIENT COMPOSITIONS

Energy	Riboflavin (B2)	Calcium
Carbohydrates	Niacin(B3)	Iron
Sugars	Pantothenic acid (B5)	Magnesium
Dietary fiber	Vitamin B6	Manganese
Fat	Folate (B9)	Phosphorus
Protein	Choline	Potassium
Water	Vitamin C	Sodium
		Zinc

THE BETTER RECIPES TO STAY HEALTHIER

1. COCO LOTUS ROOT CAKE

INGREDIENTS

- Wheat flour 70 gm
- Lotus root powder 50 gm
- Jaggery 50 gm
- Dates 5 gm
- Oil 40 ml
- Baking powder 1 ½ STD
- Baking soda ¼ STD
- Vanilla essence 1 STD

METHOD OF PREPARATION

- Lotus roots are boiled in water and cut into small pieces and sun dried to obtain the lotus root powder.
- Take all the raw and wet ingredients.
- Add wheat flour and lotus root powder well. Then add baking powder and baking soda.
- Melt the jaggery with water and remove the dirt and dust.
- Mix the flour and jaggery. Then add oil and mix them well.
- Add vanilla essence and dates and mix again.
- Pour the batter into the cake tray and bake it for 30 minutes at 180 C.
- After cooling pack the product and seal.

2. COCO LOTUS ROOT COOKIES

INGREDIENTS:

- Wheat flour - 70 gms
- Lotus root powder - 30 gms
- Butter - 25 gms
- Powder sugar - 50 gms
- Milk - 15 ml
- Baking powder - 1STD
- Baking soda - ¼ STD
- Salt - a pinch

METHOD OF PREPARATION

- Lotus roots are boiled in water and cut into small pieces and sun dried to obtain the lotus root powder.
- Take all the raw and wet ingredients.
- In a bowl add butter and sugar and mix them well.
- Add wheat flour, lotus root powder, baking powder and baking soda together and sieve well.
- Then add the dry ingredient to wet ingredients and mix well.
- A pinch of salt is added to the mixture.
- Make the dough into shapes, or balls and place them on the baking tray.
- Bake them for 15 minutes at 160 C.
- They are cooled down and packed with care.

3. COCO LOTUS ROOT NUTRITION BAR

INGREDIENTS

- Oats 70 gms
- Lotus root powder 30 gms
- Dates 20 gms
- Cashew 40 gms
- Almond 40 gms
- Watermelon seeds 20 gms
- Sesame 20 gms
- Honey 100 ml

METHOD OF PREPARATION

- Lotus roots are boiled in water and cut into small pieces and sun dried to obtain the lotus root powder.
- Roast the oats and then make them into fine powder.
- Cashew, almond, watermelon seeds and sesame roast them at low flame and the remove when they turns aromatic.
- Add both the mixture together along with the sliced dates
- Then mix the honey and mix them thoroughly.
- Place them in a tray and keep them aside for setting.
- Cut them after cooling and pack them.

4 COCO LOTUS ROOT HEALTH MIX

INGREDIENTS

- Roasted gram 70 gms
- Lotus root powder 20 gms
- Green gram 20 gms
- Cashew 10 gms
- Oats 30 gms

METHOD OF PREPARATION

- Lotus roots are boiled in water and cut into small pieces and sun dried to obtain the lotus root powder
- Roast the green gram, oats, roasted gram and cashew separately in low flame.
- Then powder these ingredients after cooling down
- Then mix all the powder together along with lotus root powder.
- Then pack the powder mix in air tight container

THANK YOU