DEVELOPMENT AND QUALITY EVALUATION OF CAKE FORTIFIED WITH *Moringa oleifera* LEAF POWDER

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PROJECT REPORT

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KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY, TAVANUR, MALAPPURAM-679573

KERALA, INDIA

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DECLARATION

We, hereby declare that this project report entitled "**DEVELOPMENT AND QUALITY EVALUATION OF CAKE FORTIFIED WITH *Moringa oleifera* LEAF POWDER**" is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this project report entitled, "**DEVELOPMENT AND QUALITY EVALUATION OF CAKE FORTIFIED WITH *Moringa oleifera* LEAF POWDER**" is a record of project work done jointly by Ms. Aquila Jabeen K K, Ms. Hanan Shana Kappil, Ms. Noorbina Razak, Ms. Shifa Rasheed, Mr. Sivakumar V under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, associateship or other similar title, of any other University or Society.

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Dedicated to the

Food Technology Profession

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List of Symbols and Abbreviations

&	: And
℃	: Degree Celsius
=	: Equal to
>	: Greater than
%	: Per cent
/	: Per
AWRP	: Arrowroot powder
C0	: Non fortified control
C1	: Selected cake
et al.	: and others
etc.	: Etcetera
E	: Egg
FAO	: Food and Agricultural Organisation
FDA	: Food and Drug Adulteration Act
Fig	: Figure
g	: Gram
I U	: International Unit
KCAET	: Kelappaji College of Agricultural Engineering and Techonology
kcal	: Kilocalorie
mg	: Milli gram
MOLP	: *Moringa oleifera* Leaf Powder
×	: Multiplication
nm	: Nanometer
PE	: Polyethylene
RBF	: Ripe Banana Flour
S	: Sugar
USDA	: United States Department of Agriculture
WHO	: World Health Organisation
β	: Beta

CHAPTER I

INTRODUCTION

Snacking is a vital pattern of consumption that supports meeting the daily nutritional needs of children, which substantially contributes to healthy growth and development (Serrano and Powell, 2013). Processed snacks are primary nutrient sources, viz. energy, protein, iron, calcium, and vitamins. In low and medium inc ome countries in Asia, Latin America, and Africa, processed snacks are becoming increasingly popular (Huffman *et al*., 2014). The consumption of snacks in South Africa was reported to increase by 53.3% from 1992 to 2012, especially among children (Ronquest *et al*., 2015). Among the snacks, cakes are one of the most popular bakery items consumed by nearly all classes of people due to their ready-to-eat nature and availability in various types at an affordable price (Ben *et al*., 2017).

Currently, baked cakes are an essential part of pre-schooler's diet to meet their nutritional demand alongside staple food. Traditional cakes are usually prepared from wheat flour, added sugar, eggs, and baking powder (Atef *et al*., 2011). However, this type of cake is high in sugar and rich in carbohydrates and fat but low in other nutrients, including protein, minerals, and vitamins (Ameh *et al*., 2013). Furthermore, the World Health Organization (WHO) reported snacks with high sugar and fat content as unhealthy (WHO, 2013).

In this context, the demand for functional food with higher nutrients and minerals has risen. Micronutrient deficiencies are most prevalent in Sub-Saharan Africa and Southern Asia, especially in women and young children (Black *et al*., 2013). Several studies reported that about 16 million children are malnourished world wide, with 2.3 million children in South Africa having stunted growth and nutritional deficiencies.

The use of locally available, inexpensive, and nutrient-rich plant materials in cake formulations must be recognized and promoted to enhance health and nutritional safety in that particular region. Moringa (*Moringa oleifera* Lam.) is an

Indian sub continent native plant that naturalized itself worldwide in tropical and subtropical regions (Moyo *et al*., 2011). Moringa is one of the most beneficial trees globally since nearly every portion of the tree can be used for food, medicines, and industrial purposes (Khalafalla *et al*., 2010). Although the leaves, flowers, and pods are used as vegetables, the tree has tremendous potential to enhance nutrition, increase nutritional safety and promote rural development (Hsu *et al*., 2006). Traditionally Moringa leaves have been used for human consumption in African countries for centuries (Daba, 2016). These leaves are excellent as a source of vitamins A, B, and C and are known as one of the best plant mineral and iron sources (Sengev *et al*., 2013). Moringa leaf was also reported to contain a high amount of protein (28.25%), iron, calcium, phosphorous, magnesium, manganese, and zinc (Nahriana and Tawani, 2019). Moreover, Moringa leaf was reported to have a high content of essential amino acids, alpha-linoleic acid and a wide range of dietary antioxidants (Oyeyinka and Oyeyinka, 2018). Moringa leaf is rich in phenolic compounds (e.g., phenolic acids, flavonoids, etc.). The anti-oxidative functionality of these compounds makes Moringa a promising natural additive that can be applied to foods for enhancing human nutrition (Devisetti *et al*., 2016). Many studies have reported the potential use of Moringa leaves in making diverse food such as soups, weaning food, herbal biscuits, bread, and yogurt (Oyeyinka and Oyeyinka, 2018). Thus, the idea was born of fortifying the Moringa leaf with other ingredients, such as arrowroot flour; to prepare a food with a better nutritional composition can increase its consumption among different populations with improved nutritional safety.

In addition, the arrowroot flour has been discovered to be used in bakery products, especially cookies. Arrowroot flour is equipped with sufficient nutritional value and processed into various types of food, i.e., wet and dry noodles, with cookies (Damat *et al*., 2017). Also, the composition of nutrition in 100 grams of arrowroot flour consists of 355 kcal energy, 0.7 g protein, 0.2 g fats, 85.2 g carbohydrate, 8 mg calcium, 22 mg phosphorus, and 1.5 mg iron. Due to carbohydrate being the predominant component, arrowroot flour is therefore considered a good source of starch (Charles *et al*., 2011). Some studies that applied arrowroot flour as the main ingredient or substitute, yielded products with higher fibre content (Astuti *et al*., 2018). Furthermore, arrowroot flour is sensorially acceptable in vermicelli products (Pepe *et al*., 2015). Arrowroot starch has a higher proportion of amylopectin than amylose, resulting in a crunchy texture in biscuit products. Since arrowroot flour contains highly useful compounds, including nutritional fibre fractions, it has a high potential for food and functional food preparation.

The prevailing literature provides data regarding the chemical components and the economic, nutritional, and medicinal value of the plant; however, the inadequacy of studies regarding the tolerable limit of fortification demands further research. Moringa leaves and arrowroot both individually and fortified in a food item, have enormous potentials to meet the nutritional demand in developing and underdeveloped countries, where high value animal protein and fruits are beyond the reach of impoverished people. However a fortificant inclusion of Moringa in various food items in a proportion that the taste remains intact and the nutritional value increases exponentially is still a challenging issue. Therefore, the current research entitled **"**Development and Quality Evaluation of cake fortified with *Moringa oleifera* leaf powder**"** was conducted to determine,

1. The nutritional composition of the cake fortified with Moringa leaf powder and arrowroot.
2. A sensory evaluation to justify consumer acceptability for improving food and nutritional security.

CHAPTER II

REVIEW OF LITERATURE

The literature reviewed for the present study entitled ‘‘Development and quality evaluation of cake fortified with *Moringa oleifera* leaf powder’’ is presented under the following sub-heads:-

2.1. NUTRITIONAL SIGNIFICANCE OF MORINGA

Moringa oleifera belonging to the family of Moringaceae is an effective remedy for malnutrition. Moringa is rich in nutrition owing to the presence of a variety of essential phytochemicals present in its leaves, pods and seeds. In fact, moringa is said to provide 7 times more vitamin C than oranges, 10 times more vitamin A than carrots, 17 times more calcium than milk, 9 times more protein than yoghurt, 15 times more potassium than bananas and 25 times more iron than spinach (Rockwood *et al*., 2013).

The fact that moringa is easily cultivable makes it a sustainable remedy for malnutrition. Countries like Senegal and Benin treat children with moringa (Kasolo *et al*., 2010). Children deprived of breast milk tend to show symptoms of malnutrition. Lactogogues are generally prescribed to lactating mothers to augment milk production. The lactogogue, made of phytosterols , acts as a precursor for hormones required for reproductive growth. Moringa is rich in phytosterols like stigmasterol, sitosterol and kampesterol which are precursors for hormones. These compounds increase the estrogen production, which in turn stimulates the proliferation of the mammary gland ducts to produce milk. It is used to treat malnutrition in children younger than 3 years (Titi and Estiasih, 2013). About 6 spoonfuls of leaf powder can meet a woman's daily iron and calcium requirements, during pregnancy. *Moringa Oleifera* is universally referred to as the miracle plant or the tree of life.

The Moringa plant derives this name based on its uses, particularly with regard to medicine and nutrition. *M. Oleifera* leaf has been used as an alternative food source to combat malnutrition, especially among children and infants (Anwar *et al*., 2007). *M. Oleifera* leaves are reported to contain substantial amounts of vitamin A, C and E (Hekmat *et al*., 2015). The leaves of *M. Oleifera* have also been found to contain appreciable amounts of total phenols, proteins, calcium, potassium, magnesium, iron, manganese and copper (Hekmat *et al*., 2015). *M. Oleifera* leaves are also good sources of phytonutrients such as carotenoids, tocopherols and ascorbic acid (Saini *et al*., 2014). These nutrients are known to scavenge free radicals when combined with a balanced diet and may have immunosuppressive effects (DanMalam *et al*., 2001). Besides the leaves, the flowers and fruits of *M. Oleifera* have also been found to contain appreciable amounts of carotenoids (Saini *et al.*, 2014).

Every part of *M. oleifera* is a storehouse of important nutrients and antinutrients. The leaves of *M. oleifera* are rich in minerals like calcium, potassium, zinc, magnesium, iron and copper .Vitamins like beta-carotene of vitamin A, vitamin B such as folic acid, pyridoxine and nicotinic acid, vitamin C, D and E also present in *M. oleifera* (Mibikay, 2012). Moringa leaves also have a low calorific value and can be used in the diet of the obese. The pods are fibrous and are valuable to treat digestive problems and thwart colon cancer (Oduro *et al*., 2008). A research shows that immature pods contain around 46.78% fiber and around 20.66% protein content. Pods have 30% of amino acid content, the leaves have 44% and flowers have 31%. The immature pods and flowers showed similar amounts of palmitic, linolenic, linoleic and oleic acids.

Moringa has lot of minerals that are essential for growth and development among which, calcium is considered as one of the important minerals for human growth. While 8 ounces of milk can provide 300–400 mg, moringa leaves can provide 1000 mg and moringa powder can provide more than 4000 mg. Moringa powder can be used as a substitute for iron tablets, hence as a treatment for anaemia. Beef has only 2 mg of iron while moringa leaf powder has 28 mg of iron. It has been reported that moringa contains more iron than spinach. A good dietary intake of zinc is essential for proper growth of sperm cells and is also necessary for the synthesis of DNA and RNA. *M. oleifera* leaves show around 25.5–31.03 mg of zinc/kg, which is the daily requirement of zinc in the diet (Fuglie, 2005).

2.2. MORINGA OLEIFERA AS A FOOD ADDITIVE

There is mounting evidence that incorporating *M. oleifera* into food and food products improves the physicochemical and organoleptic characteristics and also extends the shelf life of food. Various parts of the Moringa tree have exhibited antimicrobial activity. Food-borne diseases are rife in many parts of the world, particularly the developing world. The toll in terms of finances, human health, and suffering is enormous. There is some research evidence that *M. oleifera* may play a relevant role in the prevention of food-borne diseases. Moringa seed and leaf extracts have exhibited antimicrobial properties that inhibit bacterial growth. A study (Bukar *et a.l*,2010*)* illustrated that *M. oleifera* ethanol leaves extract exhibited broad-spectrum activity against food-borne pathogens: *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus,* and *Enterobacter aerogenes*. The same study demonstrated that *M. oleifera* seed chloroform extract showed antimicrobial activity against *E coli*, *Salmonella typhimurium*, Mucor, and Rhizopus species. The study illustrated that *M. oleifera* is capable of inhibiting the growth of certain food-borne pathogens as well as some spoilage microorganisms in food under laboratory experimental conditions. Another study (Walter *et al.,*2011*)* demonstrated the ability of *M. oleifera* to inhibit the growth of *E coli, S. typhi,* and *Vibrio cholerae*. Isothiocyanates from *M. oleifera* exhibited antibiotic activity against *Helicobacter pylori.* This pathogen is prominent in poor, medically underserved regions of the world; is a major cause of gastritis, gastric, and duodenal ulcers; and is a major risk factor for gastric cancer. Further research is desirable to explore the potential of this activity on the treatment of human *H pylori* infection. Antibiofilm potential of *M. oleifera* has been documented, and this is an important research prospect.

A recent study (Lee *et al.,* 2017) demonstrated the ability of *M. oleifera* liquid extracts to inhibit biofilm formation by a pathogen *S aureus*. Biofilm formation by pathogens plays crucial roles in their persistence and antibiotic resistance. Biofilms are microbial colonies that form when single microorganisms attach and aggregate on a hydrated surface and undergo a “lifestyle switch,” giving up life as a single cell to live on a surface in an adhesive cell matrix with other microorganisms. They are usually resistant to antimicrobial agents, and studies have revealed that cells within a particular biofilm are usually of diverse community properties.

Moringa oleifera extends the shelf life of lipid containing foods due to the presence of various types of antioxidant compounds such as ascorbic acid, flavonoids, phenolics, and carotenoids. Certain preparations may be used to preserve meat and other food products from oxidative deterioration. Oxidative stress in farm animals and lipid–protein oxidation in meat and meat products may be prevented by incorporating Moringa into animal nutrition and using Moringa extracts to fortify meat products.

A study (Moyo *et al.,*2012*)* demonstrated the antioxidative potential of *M. oleifera*. The study investigated the antioxidative effects of *M. oleifera* supplement on the activities of superoxide dismutase, catalase, lipid peroxidation, and glutathione in goats. Both acetone and aqueous *M. oleifera* leaf extracts were determined to have potent antioxidant activities, increasing the antioxidant activity of glutathione, superoxide dismutase, and catalase in the goats studied. The study attributed the antioxidative potential to the presence of polyphenolic compounds in the *M. oleifera* leaves.

Study (Nadeem *et al.,*2013*)* showed that *M. oleifera* oil improved the oxidative stability of butter oil. It improved the oxidative stability, conferred higher resistance toward shoot up of peroxide value at elevated temperature, anisidine value, and formation of oxidation products. The oil was also observed to improve the nutritional value of the butter oil by increasing the concentration of oleic acid. There is some research evidence suggesting that *M. oleifera* could be used to boost the organoleptic qualities of food and food products such as pastries and meat among others.

Research (Dachana *et al.,*2010) has demonstrated the effects of dried Moringa leaves on the rheological, microstructural, nutritional, and the overall quality characteristics of cookies. It was observed that the addition of dried Moringa leaves increased fairnograph water absorption and decreased dough stability, amylograph pasting temperature as well as peak viscosity. It also increased dough hardness, decreased cohesiveness, and spread ratio of the cookies. Furthermore, protein, iron, calcium, b-carotene as well as dietary fiber contents of the cookies increased by the end of the experiments.

Scholars (Hazra *et al.*,2012*)* treated cooked ground buffalo meat with aqueous solution of crude extract of *M. oleifera* leaves. This significantly improved meat pH and water holding capacity and lowered cooking loss and thiobarbituric acid value. It also improved the quality of the meat by enhancing the tenderness, juiciness, and preventing discoloration as well as off-flavour formation. Microbial load in terms of total plate count was found to be decreased significantly in treated samples, also demonstrating the antimicrobial activity of *M. oleifera*.

In a fairly recent study, (Manaois *et al.*,2013*)* incorporated fresh and powdered *M. oleifera* into rice crackers to serve as a dietary supplement. Not only did *M. oleifera* significantly improve the b-carotene, vitamin C, and calcium content, the Moringa rice crackers developed were shelf stable for up to 3 weeks.

Plate 1. Moringa leaf powder

Table2.1. Nutritional composition of *Moringa oleifera*

Nutrients	**Fresh leaves**	**Dry leaves**	**Leaf powder**
Calories (cal)	**92**	**329**	**205**
Protein (g)	**6.7**	**29.4**	**27.1**
Fat (g)	**1.7**	**5.2**	**2.3**
Carbohydrate (g)	**12.5**	**41.2**	**38.2**
Fibre (g)	**0.9**	**12.5**	**19.2**
Vitamin B1 (mg)	**0.06**	**2.02**	**2.64**
Vitamin B2 (mg)	**0.05**	**21.3**	**20.5**
Vitamin B3 (mg)	**0.8**	**7.6**	**8.2**
Vitamin C (mg)	**220**	**15.8**	**17.3**
Vitamin E (mg)	**448**	**10.8**	**113**
Calcium (mg)	**440**	**2185**	**2003**
Magnesium (mg)	**42**	**448**	**368**
Phosphorus (mg)	**70**	**252**	**204**
Potassium (mg)	**259**	**1236**	**1324**
Copper (mg)	**0.07**	**0.49**	**0.57**
Iron (mg)	**0.85**	**25.6**	**28.2**
Sulphur (mg)	**–**	**–**	**870**

2.3. COMMERCIAL APPLICATIONS OF MORINGA

Moringa seeds are used to extract oil called the Ben oil. This oil is rich in oleic acid, tocopherols and sterols. It can also withstand oxidative rancidity. The oil can be used in cooking as a substitute for olive oil, as perfumes and also for lubrication (Fahey, 2005). The pods can absorb organic pollutants and pesticides. Moringa seeds also have great coagulant properties and can precipitate organics and mineral particulates out of a solution (Lurling and Beekman, 2010). Chemical coagulants such as Aluminum sulfate (Alum) and ferric sulfate or polymers removes suspended particles in waste water by neutralizing the electrical charges of particles in the water to form flocs making particles filterable. *M. oleifera* seed is a natural coagulant, containing a cationic protein that can clarify turbid water. This property of *M. oleifera* seeds is attracting much research as other coagulants such as alum, activated carbon and ferric chloride are expensive and rare (Sengupta *et al*.,2012).

Suhartini *et al.*, (2013) developed a two-stage clarifier for the treatment of tapioca starch waste water by placing coconut fiber followed by a layer of sand media mixed with powdered *M. oleifera*, this lead to improvement on physical and chemical characteristics, stabilizing pH value. Moringa seed extract has the ability to eliminate heavy metals (such as lead, copper, cadmium, chromium and arsenic) from water (Ravikumar and Sheeja, 2013). *M. oleifera* functionalized with magnetic nanoparticles such as iron oxide were found beneficial in surface water treatment by lowering settling time (Santose *et al*., 2016). Seed extracts have antimicrobial properties that inhibit bacterial growth, which implies preventing waterborne diseases. These properties of *M. oleifera* seeds have wide applicability in averting diseases and can enhance the quality of life in rural communities as it is highly abundant.

Moringa seeds can be used in cosmetics and are sources of biodiesel while the seedcakes, can be used as a green manure or a fertilizer. The flowers of moringa are used to make tea with hypocholesterolemic properties. Moringa flowers are said to taste like mushrooms when fried (Arise *et al*., 2014). The moringa flowers are great sources of nectar and are used by beekeepers. The root bark has medicinal values and is used for dyspepsia, eye diseases and heart complaints (Shank *et al*., 2013). The tap root of Moringa is used as a spice. The gum from the tree can be used in calico-printing. The gum and roots also have antibacterial, antifungal and anti-inflammatory properties (Adejumo *et al*., 2012). The growth hormone from the leaves, called Zeatin is an excellent foliar and can increase the crop yield by 25%-30% (Fuglie, 2005).

Incorporation and fortification of moringa can be significant to tackle nutrient deficiencies and malnutrition. Studies have tried fortifying moringa in snacks. Aluko *et al*., (2013) did a sensory evaluation on cookies made from a mix of maize flour and moringa seed flour. The flour was mixed with different percentages of the two flours and the best acceptance was for 92.5% maize and 7.5% moringa seed flour combination. This was well accepted due to its crispness, aroma, taste and colour. Cereal gruels have also been fortified by moringa leaves in order to improve the protein content and energy. The cereal gruel with 65% popcorn and 35% moringa leaves was blanched and fermented. The fermented ones showed higher protein and energy while the blanched cereal had higher mineral content (Steve and Babatunde, 2013). Owusu *et al.,* (2011) also used moringa as a fortificant and produced cream and butter crackers with moringa and *Ipomoea batatas* as fortificants, with the hope of adding additional nutrients to snacks. The sensory evaluation proved the cream crackers to be widely accepted. *M. oleifera* leaves can be incorporated in the diet of hens and layers thereby providing excellent protein source, substituting other expensive ingredients such as soybean meal and ground nut cake (Olugbemi *et al*., 2010; Raphael, 2015).

Looking to the functional attributes and medicinal properties of moringa, the pulp can be used in various food products for value addition. The suitability of utilization of moringa pulp in various food products and evaluation of quality characteristics has not been documented. It gives new opportunity to explore the possibilities of moringa as a novel source of nutrients and phytochemicals.

Convenience foods can be categorized as ready to cook, ready to use and ready to eat products. Moringa pulp can be used as ready to use food for enhancing functional and sensory properties in various products. Traditionally moringa pods are utilized in sambhar, curries, soups etc. as adjunct to improve sensory properties and consistency of these products. The food products like dal, soup and chutney are incorporated with thickening agent to improve consistency, e.g., starch in soup, xanthan gum in chutneys. The level of thickeners can be replaced or reduced by incorporating moringa pulp as well as to improve nutritional and sensory characteristics of food products.

Considering the views of several such fortifications, it is suggested that such addition can be done to other snacks as well. Addition of moringa to the snacks can add nutritive value to the snacks. Most snacks are made up of corn meal and several studies demonstrated that a little addition of moringa to maize flour can add nutritive value to the snack in terms of protein, energy and minerals. However, further studies on moringa as a fortified Indian snack is required before bringing commercialized moringa to the market.

2.4. NUTRITIONAL COMPOSITION OF ARROWROOT

Arrowroot is an herbaceous plant that has rhizomes that grow horizontally under the ground and emit roots, leaves and branches from their knots (Lazzarotto and Ribani, 2017). The starch is extracted from rhizome, which lends itself to various combinations such as with water and milk, and consequently to the confection of various dishes. Traditionally, arrowroots sprinkle is used in the manufacture of biscuits, sweets, porridge, cakes, creams and soups. There is also use of its flour, from which *farofa* and *pirao* is made (Embrapa 2020; Moraes and Filho, 2005). It is known that arrowroot starch has unmatched characteristics and qualities conferring lightness, and high digestibility to confectionary (cakes and biscuits) (Vieira *et al.,* 2015).

Arrowroot refreshes and nourishes the body. It is a rich source of calcium, potassium, manganese phosphorus etc. It cools the body, reduces urinary symptoms like burning micturition, dysuria etc. It prevents stone formation also. It is good for genital, urinary and reproductive systems. It improves quality and quantity of semen. Reduces dysuria and leucorrhoea, fever, vomiting, diarrhoea, measles, chickenpox, burns, post-surgical etc. As it belongs to curcuma family it has got a unique property of removing toxins from our body. Toxins accumulated in our body are metabolic by-products of alcohol and drugs, colouring agents and preservatives of packed food products, insecticides and pesticides in vegetables and fruits etc. detoxification process is being carried out in livers. We can make delicious recipe like puddings, halwas, jams etc.

As for the components of rhizome, one of the pioneering studies, Erdman and Erdman (1984) evaluated the arrowroot biomass where analysis indicated that the air silage and processing residues of thick and thin arrowroot contained 10.821.1% crude protein; 11.1-30.2% crude fibre, 3.8-17% ash; and invitro digestibility of dry matter of 38.5-60.3%.

Other crops such as cassava, do not present their starch with same characteristics and easy digestibility (Souza *et al*., 2017), in addition to other attractive characteristics for the food industry, such as round and oval granules, capacity and high gelatinization temperature (Peroni; Rocha; Franco,2006). Recently there has been great interest due to its potential for use in bakery products, jellies, cakes, and baby foods (Kumalasari *et al*., 2012). Perez and Lares (2005) evaluated some chemical and mineral characteristics and functional and rheological of arrowroot, finding syneresis negative, high percentage of phosphorus, sodium, potassium, magnesium, iron, calcium and zinc in its composition and stability during cooking, which can be an interesting characteristic to be considered from the nutritional and industrial point of view.

Arrowroot rhizome has immunostimulant and antioxidant properties, in addition to being used in the production of gluten-free food, as the basis of the diet for people with celiac disease (Neves *et al*.,2005; Gopalakrishnan, 2012). The starch and arrowroot flour have a medium content of phenylalanine (10-200mg PHE/100mg of food) and therefore can be used in the diet of people with phenylketonuria (Soares, 2014). Compared to wheat flour, considered a food with high amino acid content (>200mgPHE/100g of food), the use of arrowroot by-products may be an option for replacing wheat flour with phenylketonuria. Arrowroot has been noted as an excellent alternative for replacing wheat in bakery products (Lima *et al.*,2019).

Table 2.2. Nutritional composition of arrowroot flour in 100g

Total fat	0.1g
Cholesterol	0mg
Sodium	2mg
Total carbohydrates	88.15g
Protein	0.3g
Calcium	40mg
Iron	0.33mg
Potassium	11mg

Source: USDA,2021.

2.5. FOOD FORTIFICATION

The FDA established its food fortification policy in 1980. This policy was guided by 6 basic principles. The nutrient intake without fortification is below the desirable content for a significant portion of population, the food being fortified is consumed in quantities that would make a significant portion of population, the additional nutrient intake resulting from fortification is unlikely to create an imbalance of essential nutrients, the nutrient added is stable under proper conditions of storage and use, the nutrient is physiologically available from the food to which it is being added, there is reasonable assurance that it will not result in potentially toxic intakes (Crane, 1995).

In 1923, Switzerland was the first country to fortify salt with iodine to prevent goitre and cretinism. This initiative was later followed by US in 1930. In 1932, the fortification vitamin A and D to dairy products. In 1938, voluntary enrichment of flours and breads with niacin and iron was initiated to reduce the incidence of pellagra and iron-deficiency anaemia (Hoffman, 1997). In 1974, fortification of sugar with vitamin A was initiated in Guatemala. Sugar was selected because researchers realized that no other staple food reaching all target groups. This programme reduced the prevalence of anaemia. In 1998, US includes folic acid in the fortification of wheat flour, in order to prevent the high prevalence of pregnancies affected by spina bifida and other neural tube defects (Nilson, 1998).

Food fortification for decades been used to improve the nutritional quality of food supply. The rare occurrence of rickets in children, the classical vitamin D deficiency disease, so widespread in many industrialised countries at the turn of the century, has in part been ascribed to fortification programmes. An increased intake of vitamin D through fortification of foods (milk and oils) should therefore benefit bone health (Ovesen, 2004).

Food fortification is currently implemented as a public health strategy to combat iron deficiency in many countries, either by fortification of staple foods such as milled cereal flours to reach a large proportion of population or by targeted approaches based on fortification of products consumed by vulnerable population groups, e.g., fortified commercial infant foods. Other approaches have been developed to reach individuals, who do not have access to centrally produced foods by providing micronutrients in sachets, crushable tablets, and spreads for 'in-home fortification' (Davidson, 2013).

Diet based strategies are considered to be one of the most efficient and sustainable ways to overcome iron and vitamin A deficiencies. Fortification of bakery products is given priority in recent times as more number of bakery items are liked and consumed by quite a number of people. Cake is an ideal vehicle for fortification as it is a popular snack or dessert of all age groups especially children and adolescents. As cakes are soft in texture, it is suitable for old people to consume without any difficulty of chewing. Cakes are fun to eat and are consumed in events such as gatherings, seminars, party as they have better appeal, taste, satiety and convenience, however they are low in micronutrient content but high in fat. Hence, fortification using locally available under exploited yet nutritionally rich food is a good means of enhancing the micronutrient content of cakes (Narayanan, 2015).

Food fortification has been shown to be an impactful approach to improve micronutrient status and related functional outcomes for some nutrients in some food, but there are still calls to strengthen the evidence base, particularly with programmatic evidence. Using impact pathways to guide evaluations and prioritizing impact assessment in programs with appropriate design (i.e., in populations with potential to respond and appropriate food vehicles/fortificants) and implementation (i.e., compliance monitoring and enforcement, high coverage in populations with potential to respond) could substantially increase the quality of evidence for food fortification (Neufeld, 2018).

2.6. IMPORTANCE OF BAKED PRODUCTS

People of all ages prefer bakery products, because of their taste, colour and ease in indigestion. They eat and serve different bakery products in parties and festivals. Celebrating any moment of happiness is incomplete without bakery products.

Bakery products are becoming prominent day by day. They are very popular because of their taste and easy digestabilities. Bakery items are usually loved by all. Nowadays individuals have virtually no time to invest in making breakfast; it is the breads, buns or biscuits which have replaced the conventional breakfast dishes. Honouring any occasion of pleasure is incomplete without bakery items. They take a good share of snacks and are therefore are abundantly available (Stevenrio, 2012).

Bakery products have the advantage of being ready to serve and ready to eat. Their durability, taste, and eye-catching appeal make the products popular.

Bakery products, once considered as a sickman’s diet have now become essential food items of the vast majority of people in India. Breads, buns and biscuits have become popular among all sections of the population, irrespective of age groups and economic conditions. The cause for rise in popularity of baked products is mainly due to urbanization. This has called for an increased demand for convenience products, at reasonable costs, with greater nutritional qualities and variety with different textural and taste profiles (Saurabh, 2013). Baking industry offers a large variety of products. However, its stability faces great challenges due to the heavy competition among the producers. Bakery products are the easy, readymade food items which are easily available on demand. These are available since decades, but now the liking for these items is increasing rapidly. In the present era, there are large varieties of bakery products available in the market. The popular bakery products are classified as discussed below.

Cake is a new bakery product compared to the other bakery products. It was earlier famous in the Western countries but now it is becoming popular in other parts of the world too. In olden times it was considered the food of rich homesteads and was mostly popular among Christians. But with modernization, it is gaining popularity among all the communities. It is a perishable product made for wheat flour, cream, gel, sugar and milk. It is of two types viz., egg cakes and fruit cakes.

Egg is mostly used in this to make it fluffy. Egg cakes are more perishable than fruit cakes. Cakes are used in parties and on all happy occasions. Mostly the young generations have developed the taste for this item. But the use of cakes is mostly confined to urban areas. These are not very popular in rural areas due to its low accessibility, as it is not available everywhere, except in big bakeries. Plant and machinery used in preparing cakes is expensive and needs good investment. Its scope is increasing in India also (Karaoglu *et al.*, 2009)

2.7. NEED FOR IMPROVING QUALITY OF FLOUR USED IN BAKING

In this fast age of busy work schedules; people are consuming more processed food items to suit their tight time schedules. As a generation endowed with advanced technology and greater conveniences, people are eating more processed and fast foods than ever. These unhealthy eating habits have resulted in the increase of non-communicable diseases like diabetes, obesity and some types of cancer (Sharma *et al*., 2012).

The number of diabetic and hypertensive patients in India is expected to increase to 69.9 and 213 million respectively by 2020. Cardio vascular diseases will be the largest cause of disability and deaths in India. Kerala is emerging as the "capital" of life style diseases in India with high prevalence of hypertension, diabetes, obesity and risk factors for heart diseases reaching levels comparable to those in western countries (Reddy *et al*., 2006). People are becoming aware of this serious issue of life style diseases since the last few decades. Thus functional foods have become an essential component of human diet to prevent and cure such life style disorders (Jisha *et al.,* 2008).

Recently, consumer awareness of the need to eat high quality and healthy foods-known as functional foods has increased. Functional foods are foods which contain ingredients that provide additional health benefits beyond the basic nutritional requirements. Health consciousness of consumers has increased over the years. Functional foods have attracted all sections of the population, which have been proved to prevent and control degenerative diseases.

There is a trend to produce specialty breads from whole grain flour and other functional ingredients which are known as health breads or functional foods 'Iron calla' the bread made from refined flour does not possess any of these qualities and in fact is found to be harmful in the long run. (Ndife *et al.,* 2011). Supplementing staple foods with legumes rich in lysine have been suggested to improve the nutritional status of children in developing countries. (FAO/WHO, 2003).

2.8. SCOPE OF COMPOSITE FLOUR

Composite flour can be incorporated in bakery and confectionary products, extruded products, chapatis, breakfast items, health mixes and many more popular food items. Composite flour is a blend of various ingredients which is mostly intended to replace wheat flour totally or partially in food products. The extent to which wheat flour could be replaced by other vegetable flours naturally depended on the nature of the products to be baked.

Incorporating locally available flours into food products would help to reduce the import of wheat in developing countries. Hence these governments are giving more focus on this aspect Food and Agricultural Organization (FAO) initiated this ‘composite technology ‘in 1964, by promoting indigenous crops like cassava, yam, maize, and many others for substituting wheat flour. The sensory qualities of the composite flour-based bakery products were found to be on par with the conventional products. Moreover, this concept has brought in immense variety in baked products.

Mostly the processed foods are prepared from refined wheat flour which is not healthy reported from scientific studies. More cereals and less protective foods in the diet, negatively affects nutritional status. Cereal based foods are deficient in micro nutrients. Nutrient rich materials have to be blended with nutrient deficient materials. Also, this improves the functional quality of the products.

Cereal based foods are deficient in micro nutrients. The deficiency of lysine and threonine in wheat flour can be made of by the composite flours. For example; the protein quality of both the cassava-soya and the cassava-groundnut breads is higher than that of common wheat bread (Ojure and Quadri, 2012). Nutrient rich materials have to be blended with nutrient deficient materials. This also improves the functional quality of the product.

The ingredients that can be used for preparation of composite flour are, cassava, sweet potato, taro, maize, rice, sorghum, yam, ragi, oats, barley, buck wheat, pulses, chick-pea, cowpea, mung bean, vegetables like pumpkin, bread fruit and fruits like papaya and jackfruits, as seen reported in literature. The research interest in composite flour has been on the rise in the recent past, with the aim of finding non-wheat alternatives and, thus reducing the non-wheat producing country’s dependence on imported wheat (Bugusu *et al.,* 2001).

2.9. NUTRITIONAL AND SENSORY ANALYSIS OF PRODUCTS FORTIFIED WITH MORINGA OLEIFERA LEAF POWDER

The study aimed to develop a cake fortified with moringa oleifera leaf powder (MOLP) and ripe banana flour (RBF) and assess the nutritional composition of the developed cake. It was found that the addition of MOLP and

RBF significantly increased from 5.79-8.9% for protein, 1.25-1.66% for ash, 2.7-6.9% for fibre and 53-60.88% for carbohydrate.

Although, the MOLP and RBF raised the most of the nutritional contents, the maximum consumer acceptability was recorded for unfortified control, which was statistically similar to the sample (1.5% MOLP and 2% RBF) in terms of shape, sweetness, flavour and overall acceptability. The results indicated that the supplemented with 1.5% MOLP and 2% RBF provided the enriched the nutritional quality and potentially contributed to the improvement of food and nutritional security (Roni, 2021).

The high calorie ingredients used in production of cakes has made older age group to desist from eating cakes because of the detrimental effects in the human body. A substitution approach using moringa leaf powder in peanut cake to address this effect was utilized. The proximate analysis showed an increased protein (13.8-16.68%), fat (0.86-4.5%) and crude fibre (1.2-2.24%) contents with increased addition of moringa leaf powder. Among the fortified samples, the cake with 2% moringa leaf powder addition was the most preferred in its quality index of taste, flavour and colour. (Ademosun, 2021).

The fortification of biscuit was carried out by blending wheat flour and moringa leaf powder on 1:10 ratio. The proximate analysis showed that the addition of moringa leaf powder marginally increased the moisture content from 15-16%, ash from 3.7- 4.09%, protein from 11.14-11.47% and fibre from 0.71-1.28%. The sensory results showed that the biscuit fortified with moringa leaf powder excelled in texture and taste and the general acceptability also was found to be higher for the cake fortified. (Ifediba, 2018).

In a study conducted by Simonata B, fresh pasta was formulated with by replacing durum wheat semolina with different combinations of dried moringa leaf powder, rich in fibres, minerals and antioxidant compounds. Increase in levels of MOLP influenced the technological and nutritional properties of wheat based fresh pasta. *Moringa oleifera* reduced the optimum cooking time, the swelling index and firmness. From a nutritional view point, the inclusion of MOLP enhanced the phenol content, the antioxidant activity and mineral content of fresh pasta. The products obtained had good sensorial acceptability and can make several nutritional claims due MOLP richness minerals (Simonata, 2020).

Another study conducted by Arise (2014), effect of fortification using moringa oleifera powder on the sensory and proximate attributes of fermented yellow maize and millet blend. The formulation was grouped into seven blends for maize, millet and *Moringa oleifera* flower powder (MOFP). The proximate composition of fermented yellow maize and millet (ogi) fortified with *Moringa oleifera* flower powder showed an increase in crude protein, crude fibre, ash and fat with increase in the levels of *Moringa oleifera* flower powder and decrease in carbohydrate and moisture content. Moisture, protein, fibre, fat, ash and carbohydrate contents varied in the range 7.92-9.74%, 10.46-16.06%, 2.31-4.13%, 2.90-4.07%, 1.23-1.93% and 66.45-73.25% respectively. Sensory evaluation shows that blend six (20% MOFP) compared favourably with the control. Also, nutritional analysis shows that blend six is favourable as weaning food. Therefore, blend six formulation can be used as alternative to the weaning foods to improve the nutritional status of children and help to curb protein malnutrition (Arise,2014).

CHAPTER III

MATERIALS AND METHODS

The present study entitled "**Development and quality evaluation of cake fortified with *Moringa oleifera* leaf powder**" was conducted as three experiments and the methodology adopted is discussed under the following heads.

3.1. **Selection of raw ingredients for cake**

3.2. **Development of cake fortified with *Moringa oleifera* leaf powder**

3.3. **Nutritional and sensory characteristics of cake**

3.1. SELECTION OF RAW INGREDIENTS FOR CAKE

3.1.1 Arrowroot

Arrowroot powder was procured from market.

Plate 2. Arrowroot powder

3.1.2. Processing of Moringa Leaves Flour

Moringa (*Moringa Oleifera*) is a type of local medicinal Indian herb which has turn out to be familiar in the tropical and subtropical countries. Mature green and disease-free *Moringa oleifera* leaves were collected from backyard of canteen and ladies hostel of our campus. The harvested leaves were scrubbed and spread on a sheet with even thickness at room temperature for initial drying. Afterward, the leaves were dried out using cabinet drying method and drying characteristics were noted. 50 g of Moringa leaves were distributed uniformly on trays in a cabinet at 50°C for 6 hours. The dried leaves were milled using a laboratory miller and sieved (1 mm sieve size).

Plate 3. Cabinet dryer

3.1.3. Processing of Other Ingredients

Egg, Milk, Butter, Sugar, Flavour (butterscotch) and Baking powder was also selected for the application of composite flours to cake. The process of cake involves mixing the ingredients of eggs (200 g), sugar (130 g), and cake emulsifier (15 g) together, by using a mixer for 10 mins until the mixture becomes thick and stiff.

3.2. DEVELOPMENT OF CAKE FORTIFIED WITH *Moringa oleifera* LEAF POWDER

Cake fortified with *Moringa oleifera* leaf powder were formulated by using the ingredients - Arrowroot powder, Moringa leaf powder, Egg, Milk, Butter, Sugar, Flavour (Vanilla) and Baking powder. Totally four combinations of cake were worked out and from this the best treatment was identified through sensory evaluation and was selected for quality analysis. The various treatments proposed are depicted in Table 3.

Table 3.1. Treatments for the development of Cake

Sl. No.	Treatment	E	S (g)	MOLP (g)	AWRP (g)
1	C_0	1	100	-	100(Maida)
2	C_1	1	100	5	95
3	C_2	1	100	10	90
4	C_3	1	100	15	85

(E - Egg, S- Sugar, MOLP – *Moringa Olifera* Leaf Powder, AWRP- Arrowroot Powder)

3.2.1 Standardization of Cake Recipe

- Arrowroot starch + Moringa leaf powder (100g) in varying composition (Table 3)
- Egg 1 no’s
- Milk 2 table spoon
- Butter 45g
- Sugar 100g
- Flavour (Butter scotch) ½ teaspoon
- Baking powder 2 pinch
- Pre heat the oven at 180°C for 20 minutes
- The egg was beat for 10 minutes until it forms a peak
- The flours along with baking powder was sifted
- A bowl was taken and the sugar was mixed with butter to a smooth mix
- To this sifted flour is added in little amount along with the beaten egg foam with continuous beating.
- To the smooth cake mix add the flavour and milk and beaten for a minute.

- The mixture is transferred to a mould which has been coated with butter and placed inside the preheated oven.
- Bake the cake at 130°C for 5 minutes bottom heat, 5 minutes top heated,
- 5 minutes side heated and 15 minutes even heating.
- Take the cake from oven and allow it to cool for 10 minutes and then transfer it to plate.
- The cake can be cut and used

3.3. NUTRITIONAL AND SENSORY CHARACTERISTICS OF CAKE

3.3.1. Sensory Evaluation

Sensory evaluation has an essential role in new product development with regard to its acceptability. The developed cake was presented to thirty or ten semi trained panellists. They evaluated the sensory characteristics viz; colour, appearance, flavour, texture, taste on a score card using a 9-point hedonic scale (Table 4). The scores allotted were analysed using statistical procedures to obtain a suitable conclusion.

Table 3.2: Hedonic rating scale for the sensory evaluation of cake

PARTICULATES	**TREATMENTS**			
	C_0	**C_1**	**C_2**	**C_3**
Appearance				
Colour				
Flavour				
Texture				
Taste				
Overall acceptability				

***Kindly indicate your rating between 1-9 (1 stands for poor and 9 stands for excellent)**

Like Extremely	9
Like Very much	8
Like Moderately	7
Like slightly	6
Neither like nor Dislike	5
Dislike Slightly	4
Dislike Moderately	3
Dislike Very much	2
Dislike Extremely	1

NAME:

SIGNATURE:

Totally four combinations of cake were worked out and from this the best treatment was identified through sensory evaluation and was selected for quality analysis.

3.3.2. Nutrient Analysis of The Selected Cake

Nutrient as well as chemical composition analysis refers to the process of determining the nutritional and chemical components in foods and food products. The selected combination of cake and the control cake were analysed for nutrients as well as chemical components using standard procedures.

3.3.2.1. Proximate Composition

The proximate composition of foods including carbohydrate and moisture, lipid content has done. This assessment is applicable in the food industry for product development, quality control or regulatory purposes.

3.3.2.1.a. Total carbohydrate

Carbohydrates are one of the main nutrients and are needed in large amounts by the body. The role of carbohydrates is to provide energy, as they are the body's main source of fuel, needed for physical activity, brain function and operation of the organs. All the cells and tissues in our body need carbs, and they are also important for intestinal health and waste elimination. Once in the body, carbohydrates are easily converted to fuel.

In the present study, the total carbohydrates of selected cakes were estimated by using anthrone reagent and incubating the samples in boiling water bath and recording the absorbance at 630 nm using a spectrophotometer against a blank reagent according to the method described by Hedge and Hofreiter (1962).

Plate 4. Spectrophotometer

3.3.2.1.b. Moisture level of the cake

Moisture content is one of the most commonly measured properties of food materials. Stability and quality of a food product depends upon the moisture content present in it. Moisture content was determined using a digital infrared moisture analyser. The equipment determines the moisture of a sample by heating and drying it with infrared irradiation and displays the moisture content from changes in mass due to evaporation.

Plate 5. Infrared moisture analyser

3.3.2.1.c. Fat content

Lipid is soluble in organic solvent and insoluble water, because of this, organic solvents like hexane, petroleum ether can solubilize fat. and fat is extracted from food in combination with the solvent. Hexane is the most commonly used organic solvent for the extraction of fat. Fat content determined using the automatic Soxhlet apparatus. Fat was collected by evaporating the solvent. Almost all the solvent was distilled off and can be reused.

Plate 6. Soc-plus Soxhlet apparatus

3.3.2.2 Vitamins

3.3.2.2.a. β carotene

Beta-carotene is a type of carotenoid that is found in plants. It is known as pro vitamin A carotenoid because it needs to be converted to active vitamin A by the body. Vitamin A is needed for healthy skin and mucus membranes, also for invigorating immune system and vision.

β carotene was estimated by the method of Sadasivam and Manickam (2008). This method was based upon the separation of the biologically active carotenoid pigments from the total carotenoid pigments using acetone and ether and read colorimetrically at 452 nm.

3.3.2.4. Ash content

A high temperature muffle furnace capable of maintaining a temperature between 500-700°C was used to determine ash content. Water and other volatile materials were vapourised and organic substances were burned in the presence of oxygen in the air to carbon dioxide, water and nitrogen. The weight of crucible with the sample was noted before and after burning. The percentage of ash was calculated using the equation;

% of ash = (W2-W1)/W3×100

W1= weight of crucible

W2= weight of crucible with ash

W3= weight of sample

3.3.2.5. Iron content

Iron is an important mineral in our diets. Although considered a trace mineral, diets lacking iron can contribute to the deficiency condition known as anaemia. The MOLP contain 28.2 mg iron per 100 g that can be effective in reducing the anaemic condition. The iron content was determined by using thiocyanate test. And the absorbance was measured using spectrophotometer at 458 nm.

3.3.3. Storage Studies

Shelf-life studies can provide important information to product developers enabling them to ensure that the consumers will see a high-quality product for a significant period of time after production. Just as microorganisms can grow during storage, other changes too may occur in the composition of the food. This deterioration may make the food unacceptable to the consumer. Due to such cases the changes in the food during storage may make it unsafe, due to the nature of the compounds formed. To observe the keeping quality, the product was packed in PE covers and kept for shelf-life analysis for one month.

CHAPTER IV

RESULTS AND DISCUSSION

Fortification of food is widely practiced in several foods to increase the content of essential micronutrients, to enhance the nutritional quality of the food, and to ensure higher health benefits with minimal risk to health. However, it is imperative to ensure that the fortified food and fortificant must be compatible, and the fortificant must be readily available and accessible without producing a substantial change in the fortified meal's sensory characteristics or consumer acceptability. Under the current experiment, locally available MOLP and arrowroot powder were used as fortificant to develop fortified cake, and their nutritional, sensory evaluation, and consumer acceptability were assessed. The cakes became darker in colour than the unfortified cake with the increase of MOLP concentration in the formulations. The darker colour was expected with the addition of MOLP in the formulations, as Moringa leaves contain higher concentrations of chlorophyll and are naturally dark green in colour, which causes the undesirable green tint in the fortified cakes. A similar colour change trend was also reported in several studies in cookies and snacks due to the chlorophyll concentration of the leaves used for fortification. This dark colour can adversely affect the acceptability of the MOLP-fortified cake by consumers, as it is more attractive in terms of appearance. However, nutritional and other sensory attributes of MOLP fortified cake may outweigh that limitation as people are more concerned today about health benefits rather than appearance.

4.1. SENSORY ATTRIBUTES OF FORTIFIED CAKE

The mean sensory attributes of the MOLP and arrowroot fortified cakes are presented in Table 4. The sensory qualities varied significantly among the cakes in terms of colour, texture, sweetness, flavour, mouthfeel, and overall acceptability.

However, the shape did not differ significantly among the cakes. The cake's colour changed from a light brown (control) to a dark-greenish colour with the concentration of MOLP increased in the formulation. Among the cakes, maximum sweetness and flavour value was recorded from the C2(selected cake), which was significantly higher over the non-fortified control (C0). The maximum consumer acceptability was recorded in C2, which was similar to the non-fortified control (C0).

The sensory assessments indicated that the control cake sample had the highest consumer acceptance compared with their respective cake samples containing MOLP and arrowroot powder. The lower consumer acceptance value may be due to the darker colour of the fortified cakes. These findings are consistent with earlier research, which indicated a small reduction in overall acceptability as MOLP increased (Roni, 2021, El-Gammal, 2016). However, the cake fortified with 10g MOLP rated similar in almost all the sensory attributes evaluated, which is also statistically similar to that of the unfortified control. Food products supplemented with MOLP were generally acceptable, according to (Kolawole *et al*,2013) but reported acceptance dropped dramatically as MOLP concentrations were increased for the cakes. The cake which is fortified with 10g MOLP and 90g arrowroot, shows similar acceptability as that of the control cake. The texture of the cake was found to be of less acceptability to consumer because of the lack of binding agent. To overcome that, we can add a small amount of maida along with arrowroot in the cake formulation to improve the texture of the fortified cake, since texture is a main factor that affect the consumer acceptance and appearance. Thus a fortified cake having a good overall acceptability can be made to overcome the malnutrition.

Plate 8. The cake samples with different MOLP formulations

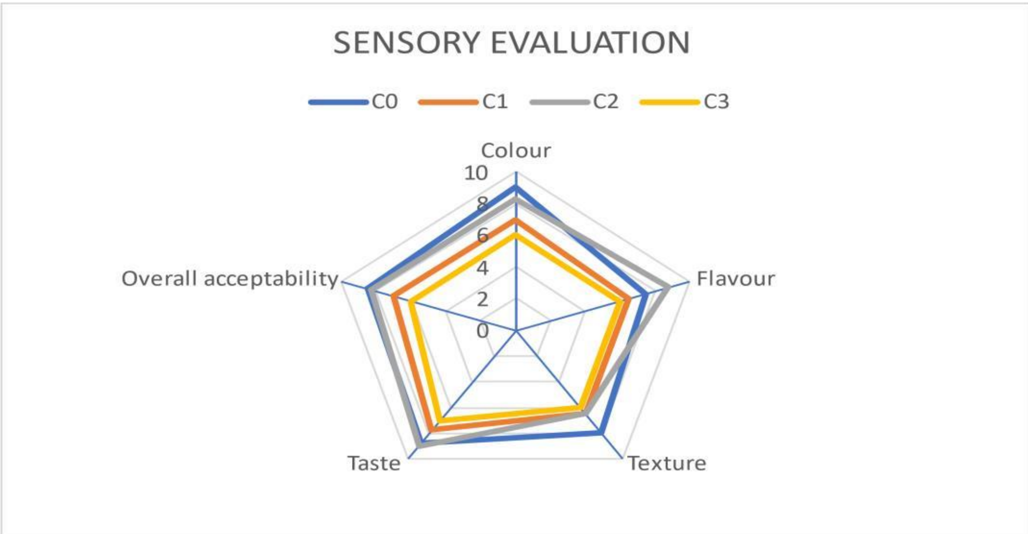

Fig1. Sensory evaluation the cake samples

4.2. PROXIMATE COMPOSITION OF THE FORTIFIED CAKE

Proximate composition of the developed cake fortified with MOLP and arrowroot has been done. The moisture content of cake slightly increased from 14.56 to 15.45% with the increased substitution of MOLP in the cake. Studies shown that, the safe moisture content of cake varies from 15-30%, so that our product will be shelf stable for a few months for at-least 3 months. The ash content significantly increased as the substitution level of MOLP increased.

4.2.1. Total Carbohydrate (g/100g)

The total carbohydrate of cake found to be slightly higher for fortified cake (33g) than that of unfortified cake(25g). This may be due to the increase in fiber content with the addition of MOLP.

4.2.2. Moisture Content (%)

The moisture content found to be slightly higher for the fortified (15.4%) than the unfortified (14.5%). The safe moisture level of cake was reported to be 15-30%. So, a shelf life of at-least 3 months is possible under refrigeration.

4.2.3 Fat Content (g/100g)

It was found that the inclusion of MOLP in the cake resulted in the fat content of cake. The fat content changes from 0.6g to 0.2g as the MOLP in the cake formulation increased. The moringa leaf contain a lower level of fat, which may facilitate shelf stability of a food product, minimizing rancidity development.

4.2.4 Crude Fibre (%)

Crude fibre of fortified cake was found to be 2.6% whereas in unfortified cake, it is found to be only 0.35%. Higher fibre content further provides numerous health benefits such as maintenance of bowel integrity, lowering blood cholesterol and controlling sugar levels (Aleixandre, 2016).

4.3. VITAMIN A

Vitamin A content of fortified cake (2.88 IU) were significantly higher in comparison to the vitamin A of unfortified cake (0.004 IU). This also clearly depicts that, the vitamin A content of cake sample significantly increased with the increment of MOLP substitution in the flour blend. It has reported that, the dried leaves of Moringa contain 10 times higher vitamin A than carrots. Thus, the significant increment of vitamin A in the fortified cake than the unfortified cake,

4.4. ASH CONTENT (%)

The ash content also shows an increasing trend as the MOLP in cake formulation increased. The ash content of unfortified cake was found to be 1.82%, whereas, in the fortified cake, it was found to be 3.34%. Thus, the total mineral content increased with increase in MOLP in cake.

4.5. IRON CONTENT (mg/100g)

Iron content of fortified cake was found to be 12.59mg, which is higher than the unfortified which contain only 0.96mg. So, it is clear that, the fortification of the cake with MOLP increased the iron content, which is highly beneficial for the anaemic patients.

Plate 7. Analysis of iron content

CHAPTER V
SUMMARY AND CONCLUSION

Food fortification for decades been used to improve the nutritional quality of food supply. It is currently implemented as a public strategy to combat the micronutrient deficiency in many countries. Diet based strategies are considered one of the most efficient and sustainable ways to overcome the vitamin A deficiencies and all. Fortification on bakery products is given priority in recent times as more bakery items are liked and consumed by quite number of people. Cake is an ideal vehicle for fortification as it is a popular snack of all age groups especially children and adolescents.

Moringa leaf fortification in food dishes has proven to be beneficial for human health. So-many studies shows that, the fortification of moringa oleifera leaf powder added to daily food can increase the body weight of malnourished children. The addition of moringa oleifera improves the anaemic status, indicated by an increase in the red blood cells, haemoglobin and haematocrit.

The current study on the fortification of MOLP with arrowroot powder in cakes can be used as a tool for preventing the malnutrition. The high vitamin A and iron content of MOLP has increased the overall nutrient content of the cake. Moringa contains 10 times higher vitamin A than carrot and 25 times high iron content than that of spinach. The addition of arrowroot powder in substitution of all purpose flour make the people who are suffering from celiac disease to eat cake without any harmful effect. Also the arrowroot have a lower glycaemic index. The nutritional anlysis showed the increased nutrition in cake as the MOLP in the cake formulation increased. There is an increase in vitamin A content from 0.004IU to 2.88IU, 0.96 to 12.59mg/100g iron, 1.39g to10.02g/100g protein, 25 to 33g/100g of total carbohydrate and 0.35g to 2.6g/100g crude fibre, as the MOLP increased in the cake formulation. The fat content found to be decreasing from 0.6 to 0.2g as MOLP in cake increased. The sensory evaluation of the cake samples were also done to find out the overall acceptability of the cake.

Fortification of cake with MOLP and arrowroot powder collectively resulted in enhanced nutritional, mineral, and vitamin A contents of the fortified cake. Sensory evaluation of the study revealed that the acceptability of the snacks decreased as MOLP concentration was increased, but the cakes containing 10g MOLP and 90g arrowroot powder were almost as acceptable as the control cake.

Furthermore, the MOLP- and arrowroot powder-enriched cake’s high vitamin A content may help developing countries combat vitamin A deficiency. Overall, the research demonstrates that fortifying cakes with 10g MOLP and 90g arrowroot powder can enhance nutrient content and contribute to better food and nutritional security.

CHAPTER VI

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DEVELOPMENT AND QUALITY EVALUATION OF CAKE FORTIFIED WITH *Moringa oleifera* LEAF POWDER

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ABSTRACT OF PROJECT REPORT

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ABSTRACT

The research paper depicts the development and quality evaluation of cake fortified with Moringa oleifera leaf powder. Micronutrient deficiency is raising concern worldwide, especially among children and pregnant women in Africa, southern Asia, and certain developing countries, posing a significant risk to the nutritional states. This study aimed to develop cake fortified with moringa leaf powder (MOLP), Arrowroot powder (AWRP) and assessed the effect of MOLP and AWRP on the nutritional composition as well as consumer acceptability. The nutritional, minerals, vitamin, and sensory attributed of MOLP and AWRP fortified cakes are assessed. Proximate analysis results showed that the addition of MOLP and AWRP significantly increased from 1.39% to 10.02% for protein, 25% to 33% for carbohydrate, 0.35% to 2.6% for fiber, 0.96% to 12.59% for iron. Moisture content of the fortified cake (15.4%) is higher than that of unfortified cake (14.5%) Moringa leaf contain a lower level of fat. Fat content changes from 0.6g to 0.2g as the MOLP in the cake formulation increased. Vitamin A content in fortified cake (2.88 IU) is significantly higher compared to Vit A of unfortified cake (0.004 IU). Although MOLP and AWRP substitution raised most of the nutritional contents, the maximum consumer acceptability was recorded in the unfortified control, which was similar to C2 (10g of MOLP and 90g AWRP) substitution in terms of shape, sweetness, flavor, mouth feel and overall acceptability