

**A DISSERTATION ON
VALORIZATION OF CITRUS LIMETTA PEEL INTO HIGH FIBER
MUFFINS**

**SUBMITTED TO THE
DEPARTMENT OF BIOSCIENCES
FACULTY OF BIOSCIENCES
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**IN PARTIAL FULFILMENT
FOR THE
DEGREE OF MASTER OF SCIENCE
IN BIO TECHNOLOGY**

BY

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M.Sc. Biotechnology (IV Semester)

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UNDER THE SUPERVISION OF

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CERTIFICATE

Certificate that Ms **Sara Thapa** (Enrollment Number 1700103694) has carried out the research work presented in this thesis entitled “**Volarization of Citrus Limetta Peel into High Fiber Muffins**” for the award of **M.Sc. Biotechnology** from Integral University, Lucknow under my supervision. The thesis embodies results of original work and studies carried out by the student himself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

I wish her good luck and bright future.

Er. Poonam Sharma

(Supervisor)

Assistant professor

Department of Bioengineering



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TO WHOM IT MAY CONCERN

This is to certify that **Sara Thapa**, a student of **M.sc Biotechnology** (II Year/ IV Semester), Integral University has completed her four months dissertation work entitled “**Volarization of Citrus Limetta Peel into High Fiber Muffins**” successfully. She has completed this work from Integral University under the guidance of Er. Poonam Sharma. The dissertation was a compulsory part of her **M.sc Biotechnology degree**.

I wish her good luck and bright future.

Dr. Snober S. Mir

Head of Department of Biosciences

Faculty of bioscience

DECLARATION FORM

I, **Sara Thapa**, a student of **M.sc Biotechnology** (II Year/ IV Semester), Integral University have completed my four months dissertation work entitled “**Volarization of Citrus Limetta Peel into High Fiber Muffins**” successfully from **Integral University, Lucknow** under the able guidance of Er. Poonam Sharma, (Assistant Professor), Department of Bioengineering, Integral University Lucknow.

I, hereby, affirm that the work has been done by me in all aspects. I have sincerely prepared this project report and the results reported in this study are genuine and authentic.

Name: -Sara Thapa

Date: -

Dr. Mohd. Salman Khan
(Course Coordinator)

ACKNOWLEDGMENT

I would like to thank all with a deep sense of gratitude who gave me possibility to complete this project on right time.

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Thank you.

Sara Thapa

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Abstract

The objective of this study is to develop muffins by addition of mosambi peels as mosambi peels are rich source of Vitamin C and fibers and which can boost immune and improve digestion. The Mosambi peels are bitter in taste so de-bittering was done using Sodium Chloride solution at different concentration (8-12%). The de-bittered mosambi peels were added in muffins at different concentration ranged from 5-30%. The proximate analysis of muffins showed that on increasing the peel powder concentration the moisture and ash content increased gradually. The sensory evaluation of muffins showed the taste, colour, texture and overall acceptability of muffins also decreased with increasing the peel powder concentration. The overall acceptability of muffins was good. It resulted in positive outcomes and can be further improvised at the industrial level.

Key words: Mosambi peel, Muffins, De-bittering, Sensory analysis, Proximate Analysis

1. Introduction

Mosambi (sweet lime) belonging to the family Rutaceae is a citrus fruit grown mostly in the Southeast Asia. Mosambi is popular in India and usually bears fruit within 5–7 years. It is a rich source of water-soluble vitamin, vitamin C, minerals and total polyphenols and has good antioxidant properties. Mosambi (sweet lime) possesses several health benefits as it aids digestion and helps in curing scurvy, diabetes, urinary disorder and skin problems. Mosambi is fibre-rich fruit with low-glycaemic index.

Citrus having origin in the family of *Rutaceae* are one of the extensively cultivated fruits in the whole world. Orange (*Citrus sinensis*), Mandarin (*Citrus reticulata*), Lemon (*Citrus limon*), lime (*Citrus aurantiifolia*), and grapefruit (*Citrus paradisi*) are some of the important commercially grown citrus fruits in the world (Rashid et al., 2013). Although it is believed that at least 4000 years ago, "the tropical and subtropical regions of the Asian continent and the Malaysian archipelago" had begun to plant citrus trees, there is still uncertainty on the true origin of citrus cultivation (Berk, 2016a). Different researchers have specified different origin histories for specific citrus fruits. Rouseff, Perez-Cacho and Jabalpurwala (2009) state that sweet oranges have their origin from India, trifoliolate orange plus mandarin originated in China, and an acidic variety of citrus. Citrus fruits are enriched with numerous phytochemicals and bioactive components, having health-

promoting properties. In addition, they are rich sources of vitamin C, folic acid, potassium, and pectin (Rafiq et al., 2018). Citrus fruits have acquired great interest because of the high polyphenols mainly flavonoids and antioxidant content. Flavanones such as naringin and hesperidin are usually found in tissues and peels of citrus fruits, displaying numerous therapeutic advantages due to their anti-oxidative, anti-inflammatory, and anti-carcinogenic properties (Espinosa-Pardo, Nakajima, Macedo, Macedo & Martinez, 2017).

Citrus fruits are widely consumed owing to their appealing taste, fragrance, and nutritional qualities. All citrus varieties have a similar anatomical structure, citrus fruits were only traded and consumed as fresh fruits, even in regions that did not produce citrus fruits. This is due to the extraordinary stability during the post-harvest of citrus that promotes global trade, and in most citrus varieties, the fruit can be hung on the tree for a longer duration after maturity without spoiling. However, with the constant growth of plantation area and the size of the crops, the industrialization of citrus fruits has become inevitable. Industries that produce jams, jellies, and marmalades, and essential oil extraction centers which utilize citrus fruits have been active for years. History says that the large-scale utilization of citrus fruits began with fruit juice industries established in California and Florida in the 20th century (Berk, 2016a). Out of the total global citrus fruit production, around 18% are utilized for industrial usage (FAO, 2017), especially

for juice production. Citrus fruits are also processed in the canning industry for the preparation of marmalade, mandarin segments as well as for recovery of bioactive essential oils and flavonoid compounds.

The by-products derived from mosambi wastes can act as a source of nutraceuticals, and low-cost nutritional dietary supplements can be produced in pharmaceutical, nutraceutical and food industries. Citrus juice production leads to the generation of waste which is practically 50% of the fresh fruit mass. This waste includes peels (50–55% of the total fruit mass), seeds (20–40% of total fruit mass), pomace, and wastewater. Citrus wastewater covers portions of spoiled fruit, seeds, pulp, and peels. Citrus fruit waste peels (flavedo and albedo), seeds, and pomace are viewed as potential bio-resource material for several purposes. Because of the bioactive compounds present in citrus processing wastes, they have numerous health benefits and can be used for the preparation of designer foods. Also, different components of citrus waste can be extensively explored in food industries as additives in the preparation of candied items for confectionary/bakery industries or as a source of pectin, color. The objectives of this work are:

- 1) De-bittering of *citrus limetta* peel.
- 2) Optimization of muffin recipe
- 3) Proximate analysis of high fiber muffins.

2. Review of literature

Mosambi peel

Citrus fruits and juices are important sources of bioactive compounds including antioxidants such as ascorbic acid, flavonoids, phenolic compounds, and pectin which are important for human nutrition (Ebrahimzadeh, Hosseinimehr, & Gayekhlou, 2004; Fernández-López, Zhi, Aleson-Carbonell, Pérez-Alvarez, & Kuri, 2005; Jayaprakasha & Patil, 2007). Mosambi (*Citrus limetta*) is a species of citrus that belongs to the family Rutaceae. It is extremely valued throughout the world for its exceptional nutritional and medicinal properties (Tanaka, 1994).

Mosambi fruits are mostly used by juice processing industries, whereas the peel and seeds are usually thrown as waste. Since the juice yield of citrus is less than half of the fruit weight, very large amounts of byproduct wastes such as peel and seeds are generated every year (Manthey & Grohmann, 2001). The citrus wastes are rich in nutrients and contain many phytochemicals that can be efficiently used as components in pharmaceutical drugs or as food supplements (Middleton, Kandaswami, & Theoharides, 2000).

The main byproducts of citrus processing are the peel, pulp, and seeds, which account for 40–60% of the weight of the raw material (Licandro & Odio, 2002). Although most of the citrus byproducts are used for animal feed (Ting & Rouseff, 1986), many useful byproducts can be obtained from different portions

of the citrus fruits, such as pectin, marmalades, candied peel, beverage bases, molasses, peel seasoning, purees, dried pulp, citrus alcohol, bland syrup, citric acid, seed oil, and flavonoids (Braddock,1995; Braddock & Cadwallader,1992; Licandro & Odio,2002). Mosambi peels are rich in pectin which is known to possess blood sugar-lowering and cholesterol-lowering properties (Baker,1994). Mosambi peel can be incorporated in jam as a source of pectin

Nutritional Value

Mosambi is a good source of vitamin C and potassium and also contains some fiber, magnesium, iron, phosphorus, and calcium shown in table 1.

Table 1: The nutritional composition of Mosambi based on diet of 2000 calories per day.

Nutritional info	
Carbohydrates	11 gm
Dietary fiber	3g
Sugar	1 gm
Potassium	490 mg
Vitamin A	1%
Vitamin C	60%
Calcium	3%
Iron	8%

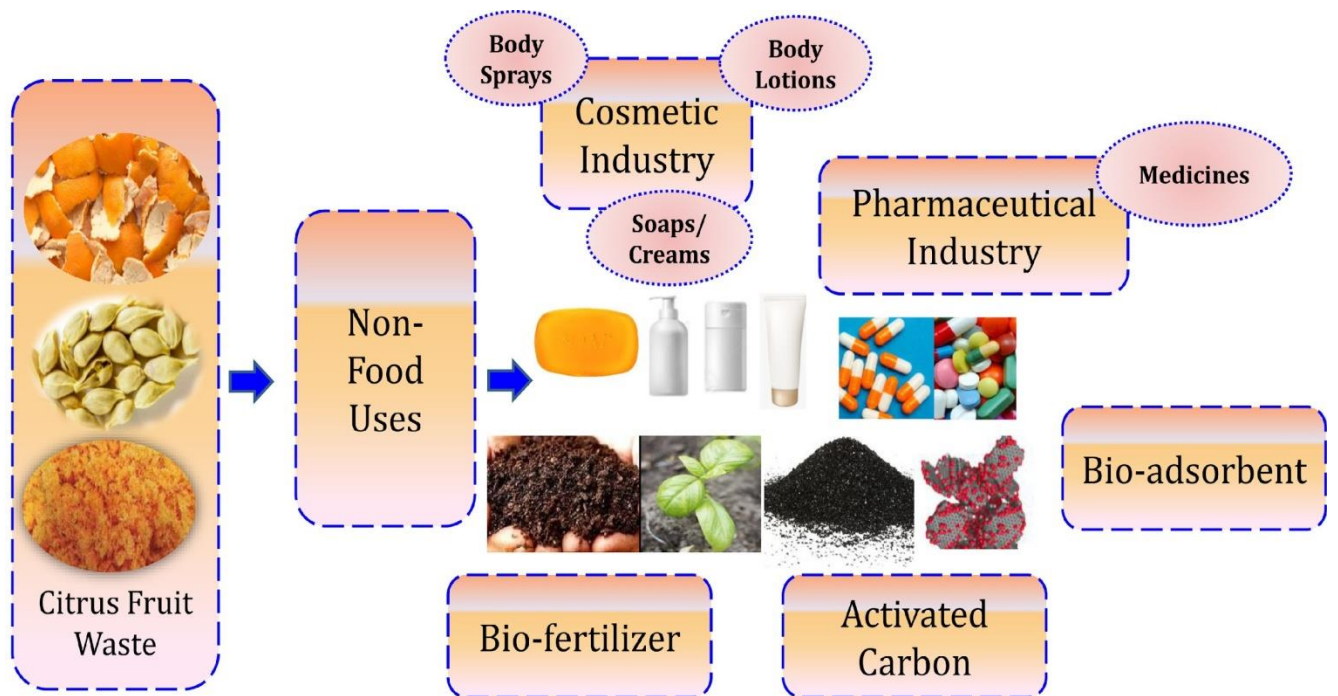
Application of citrus fruit processing waste

Owing to the valuable functional constituent present in citrus waste and with increasing concern on waste valorizations, researchers are utilizing citrus waste in several useful ways, minimizing the environmental damage caused due to improper waste disposal. Citrus waste constituting peels, pulp, pomace, and seeds contains several bioactive phytochemicals like pectin, essential oil, polyphenolic-flavonoids, carotenoids, dietary fiber, limonoids, organic acids, and vitamins (Di Donna et al., 2020). These compounds from the citrus waste could be extracted and utilized for the preparation of functional foods and nutraceuticals (Zhu et al., 2020). These bioactive components not only serve as a functional ingredient but also safeguard one's health against microbes, allergies, and illness (Babbar, Oberoi, Uppal&Patil, 2011).

Mosambi is native to northern India, specifically Nagaland and Meghalaya, and has been found growing wild since ancient times. The fruit was then spread across Asia and into Europe via trade routes and to the United States around the turn of the 19th century. Today Mosambi is mostly cultivated as a specialty home garden plant in Florida and California in the United States, but it can also be found growing in Southeast Asia, India, Egypt, Pakistan, Syria, and the Mediterranean.

Citrus waste is also used as animal feed, for preparation of compost, and certain bio-fuels and bioethanol (Bernal-Vicente, Ros, Tittarelli, Intrigliolo&Pascual,

2008; Casquete et al., 2015). The solid and concentrated liquid citrus waste could be converted into ‘citrus waste-based molasses’, lactic acid, feed yeast, industrial alcohol/ethanol as well as vinegar (Di Donna et al., 2020). Recently, utilization of citrus waste for the development of nanoparticles of iron as well as silver having cytotoxicity (Ahmed, Kaur, Sharma, Singh & Ikram, 2018; Wei, Fang, Zheng, Tan & Tsang, 2016), nanocellulose (Marino, Lopes da Silva, Duran & Tasic, 2015), and enzymes like pectinase (Garzon & Hours, 1992), larvicides (Akram, Khan, Hussain & Hafeez, 2011) have been suggested. Applications of different parts of citrus waste in food and non-food sector:



Citrus peel

In the course of preparation of juice from citrus fruits, around 30–34% of citrus peel is attained as the prime waste product (Rafiq et al., 2018). Citrus peels contain a plentitude of phytochemicals and bioactive constituents, for instance, polyphenols-flavonoids (polymethoxylated flavones- hesperidin, naringin, nobiletin, tangeretin), essential oils (D-limonene), pigments (carotenoids), carbohydrates (pectin, cellulose, hemicellulose, and dietary fibers), flavoring compounds and pigments (Wang, Chen & Lu, 2014). Being a potent source of phytochemicals, citrus peel is utilized in foods, beverages, perfumery, drug, and cosmetic industry

Food application

Dietary Fiber

Recently, dietary fiber is in high demand as a dietary supplement and as an ingredient in natural and engineered foods. Fiber obtained from citrus peel is a rich source of soluble and insoluble fiber, widely considered for its potential nutritional and health benefits (Berk, 2016b). In the literature, citrus peels are used to extract dietary fiber, using a variety of different technologies, including ultra-sonication, acid-alkali treatment, enzymes, dry/wet treatment, and a combination of these methods (Yang, Ma, Wang & Zheng, 2017). In a study, the steam explosion and dilute acid soak method was successfully used to extract dietary fiber from the

peels of *Citrus sinensis*, where improved the yield of soluble fiber (33.74%) was observed which suggests its use as a potential ingredient in the food (Wang, Xu, Yuan, Fan &Gao, 2015).

Food Additives

Food additives are substances that impart flavor, color, taste and nutritional qualities to the food product. With the increasing consumption of organic food materials, more focus is laid on the inclusion of natural additives obtained from agro-food processing waste. Waste generated from the food processing industry comprises of bioactive components having antioxidant activity, which could be a natural substitute for synthetic food additives (Zhu et al., 2020). As per European Union Regulation 1333/2008, Food additive is "any substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of a food, whether or not it has nutritive value, the intentional addition of which to a food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may be reasonably expected to result in it or its by-products becoming directly or indirectly a component of such food" (Saltmarsh, 2020).

Owing to their unique flavor, color, and nutritional quality, citrus peel and rind are widely utilized as food additives in the preparation of candied items for confectionary/bakery industries. The worldwide bakery products market arrived at

a worth of nearly USD 507.38 billion in 2020. The bakery sector is additionally expected to develop at a CAGR of 2.5% in the coming years to arrive at a worth of nearly USD 574.05 billion by 2026 (Anonymous, 2021). Globally, biscuits have the largest market share in the bakery sector followed by bread & rolls, cakes & pastries, and rusk.

With the advent of technology, different sections of citrus waste could be processed and incorporated into baked items leading to not only enhancement of nutritional value but also effective utilization of waste.

Phenolic compounds

Major bioactive compounds known for health benefits are phytochemicals, especially phenolics in fruits and vegetables. Studies have reported that plant phenolics are not only present in edible parts of plant but their presence with multiple biological effects has also been reported in non-edible parts of the plants. The mechanisms behind the contribution of phytochemicals in health promotion and disease prevention are related to cell differentiation, pro-carcinogenes deactivation, DNA repair maintenance, suppression of N-nitrosamine formation and change of oestrogen metabolism, amongst others (Shahidi, 1997). Major mechanisms for the antioxidant effect of phenolics in functional foods include free radical scavenging and metal chelation activities. Reactive oxygen species (ROS), such as the superoxide radical, hydrogen peroxide (H₂O₂), hypochlorous acid

(HOCl) and the hydroxyl radical (HO[•]) have found to be supportive in pathogenesis of human beings. (Halliwell, 1996, Halliwell et al., 1992, Aruoma, 1994, Aruoma, 2003). Phytochemicals provide effective means for preventing and treating free radical-mediated diseases such as cancer (Huang et al., 2001), diabetes (Boynes, 1991), neurodegenerative diseases (Perry et al., 2000), process of ageing (Hensley and Floyd, 2002) and cardiovascular dysfunctions by scavenging free radicals and quenching ROS (Hool, 2006). In addition, many of the antioxidants found in plants exhibit a wide range of biological effects, including antibacterial, antiviral, anti-inflammatory, antiallergic, antithrombotic and vasodilatory actions (Cook and Sammon, 1996).

One of the most popular world fruit crops namely citrus (*Citrus L.* from Rutaceae) contains a host of active phytochemicals that can protect health. In addition to this, it provides an ample supply of vitamin C, folic acid, potassium and pectin. Citrus species of various origins have been evaluated for their phytochemical composition and its contribution in health promotion (Proteggente et al., 2003, Gorinstein et al., 2004, Anagnostopoulou et al., 2006, Guimarães et al., 2009) and it has been recognized that citrus species exhibit promising biological properties including antiatherogenic, anti-inflammatory, antitumor activity, anticlotting and strong antioxidant activity (Middleton and Kandaswami, 1994, Montanari et al., 1998, Samman et al., 1996). During the winter months a citrus fruit variety grown in

north Indian states, mainly in Punjab and Rajasthan namely Kinnow or Tangerine (*Citrus reticulata*) is processed into juices by the industry and fruit vendors and 30–34% of kinnow peel is obtained as a major processing by-product. This Kinnow peel is found to be a rich source of health beneficial compounds including vitamin C, carotenoids and polyphenolic antioxidants (Anwar et al., 2008). On the other hand the major causes of food deterioration especially meat products are lipid oxidation and auto-oxidation. Synthetic antioxidants have been used from years to prevent this lipid oxidation which may produce changes in meat quality parameters such as colour, flavour, odour, texture and even nutritional value (Fernandez et al., 1997). To overcome the disadvantages of using synthetic anti-oxidants in meat products, Devatkal et al. (2010) replaced them with kinnow rind powder extract successfully and the results revealed that extracts are rich sources of phenolic compounds having free radical scavenging activity and concluded that the extracts of citrus powders have potential to be used as safer alternative to synthetic ones. Another encouraging study was carried out by Benamrouchea and Madania (2013) to confirm that by-products (peels and leaves) of two orange varieties cultivated in Algeria (*Citrus sinensis* L. and *Citrus aurantium* L.) as potent antioxidants. During the last decade interesting phytochemicals such as 4'-Geranyloxyferulic (GOFA) and boropinic acid have been discovered as valuable pharmacological effects as cancer chemo preventive, anti-inflammatory, neuroprotective, and anti-

helicobacter pylori agents. *C. sinensis* and kumquat (*Fortunella japonica*) are the richest sources of phytochemicals such as GOFA (0.141 ± 0.011 mg/g of exocarp fresh weight) and boropinic acid (0.206 ± 0.002 mg/g of exocarp fresh weight) respectively (Genovese et al., 2014). Comparative literature data on total phenol content of peel (flavedo + albedo) extracts of citrus fruits measured by the Folin–Ciocalteu assay

Flavonoids

Flavonoids are polyphenolic compounds having a phenyl benzopyrone structure, representing as two benzene rings (C6) joined by a linear three-carbon chain (C3), with a carbonyl group at the C position. Although flavonoids are generally regarded as non-nutritive agents, their potential role in the prevention of major chronic diseases has attracted the focus of many researchers. The citrus flavonoids include a class of glycosides, namely, hesperidin and naringin and another class of O-methylated aglycones of flavones such as nobiletin and tangeretin, which are relatively two common polymethoxylated flavones (PMFs) (Li et al., 2014). In citrus fruits, peels are reported to possess highest amounts of PMFs compared to other edible parts of the fruit (Manthey and Grohmann, 2001, Wang et al., 2014). The citrus flavonoids have been found to have a health-related property, which include anticancer, antiviral and antiinflammatory activities, reduce capillary fragility, and restricts human platelet aggregation (Huet, 1982, Benavente-Garcia

et al., 1997). Some glycosylated flavanones can be easily converted into the corresponding dihydrochalcones, which are potent natural sweeteners (Bor et al., 1990). The wide biochemical functions of flavonoids in orange peel have been studied extensively recently. They increased serum antioxidant capacity against lipid peroxidation (Assini et al., 2013) and reduced the elderly oxidative stress. These compounds possess the beneficial effects of anti-inflammation, antitumor (Romagnolo and Selmin, 2012; Park and Pezzuto, 2012), and antiatherosclerosis (Mulvihill and Huff, 2012). In Addition to this, these also serve as supplementary of drug chemotherapy (Meiyanto and Hermawan, 2012), diabetes health food (Aruoma et al., 2012), and neuroprotective drug (Hwang et al., 2012). Ramful et al. (2010) examined flavedo extracts of different varieties of citrus fruits grown in Mauritius for their total phenolic, flavonoid and vitamin C contents and antioxidant activities. Flavonoid derivatives, expressed in quercetin equivalents, in Mauritian citrus flavedos were generally high (>2000 µg/g FW for the majority of samples analysed) and the reason probably might be high sunlight conditions which could induce the accumulation of flavonoids (Li et al., 1993). Using the same assay system but with Catechinas standard, three types of flavonoids generally occur in citrus fruits: flavanones, flavones and flavonols. HPLC analyses of nine flavedo extracts showed that the flavanone glycoside hesperidin is found to be present in highest concentrations (83–234 mg/g FW) in all the extracts (Londono-Londono et

al., 2010). The flavanones glycosides poncirin, didymin, narirutin and flavone glycosides diosmin and isorhoifolin were present in all flavedo extracts where as the flavanone glycoside naringin was present only in Mandarin variety (Tomás-Barberán and Clifford, 2000). Several reports highlighted the structure–antioxidant activity relationship of flavonoid subclasses in citrus extracts. Data evidence suggests that glycosylation, O-methylation, O-glycosylation influence greatly the antioxidant potency of citrus flavonoids (Di-Majo et al., 2005). Antioxidant activity decreases with glycosylation and was enhanced with hydroxylation and the presence of C2–C3 double bond in conjugation with a 4-oxo function (Rice-Evans et al., 1996). Strong associations between high dietary intakes of natural compounds with a reduced risk in development of neurodegenerative diseases, such as Alzheimer’s disease, Parkinson’s disease, amyotrophic lateral sclerosis and multiple sclerosis have consistently been reported in numerous epidemiological studies (Glass et al., 2010). These natural compounds possessed neuroprotective ability and resulted suppression of activated microglia-mediated neuroinflammation (Lee et al., 2003, Pan et al., 2008; Zheng et al., 2008). Dried tangerine peel (*Citrireticulatae*) is used as traditional Chinese medicine, pericarpium called chen-pi to cure a wide array of ailments, including bronchial asthma, dyspepsia, and cardiac circulation, (China Pharmacopoeia Committee, 2010). A number of scientific studies report it as a rich source of many flavonoids,

especially flavanone glycosides and polymethoxy flavones, which play a great contribution in protection against life threatening diseases such as cancer, atherogenesis, (Tripoli et al., 2007; Benavente-Garcia and Castillo, 2008) and neuro-degeneration disorders (Youdim et al., 2004; Hwang et al., 2012). Inhibiting microglial activation-mediated neuroinflammation has become a convincing target for the development of functional foods to treat neurodegenerative diseases. Tangerine peel (*Citrireticulataepericarpium*) has potent anti-inflammatory capacity; however, its anti neuro-inflammatory capacity and the corresponding active compounds remain unclear. Hesperidin has been found as the most predominant flavonoid in tangerine peel, followed by tangeretin and nobiletin. It has been reported that hesperidin, nobiletin, and tangeretin individually possess mild inhibitory activity against neuroinflammation but their collective effect is found to be significant (Su-Chen and Chun-Ting, 2014).

3. Material and method

3.1 Sample collection area

Mosambi peel was collected from local vendors of Lucknow city located in Uttar Pradesh, India.

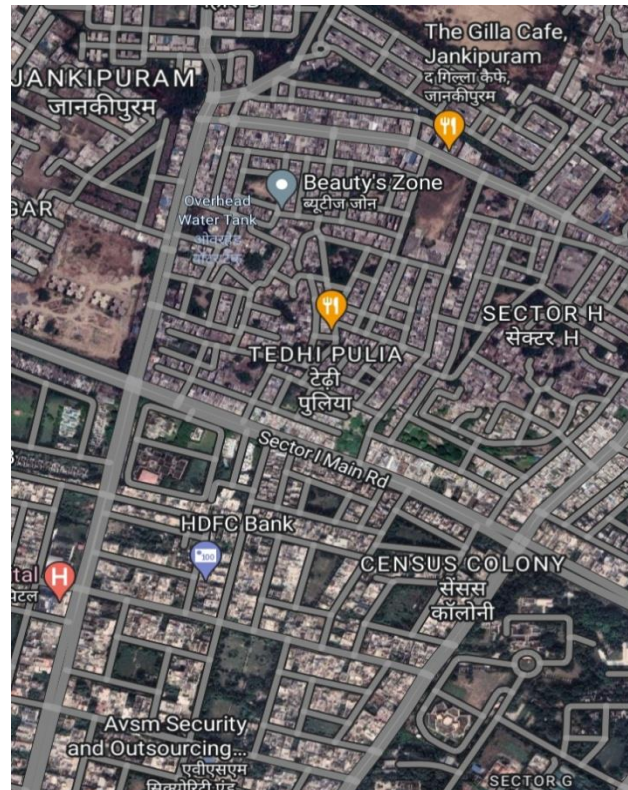


Figure 3.1- Sattelite map location of study area

3.2- Preparation of peel

Peel was washed with potable water to remove the dirt or any extraneous matter and then blanched to reduce the microbial load. The peel was then grinded in a lab grinder (Sunflame Legend 750-watt Mixer Grinder by Sunflame India) and then collected and stored under refrigerated condition till further analysis.

3.3-De-bittering of peel

Mosambi peel was treated with salt for de-bittering using different combinations of sodium chloride concentration (0–12%) and soaking time (4–24 hr). The de-bittering was done by addition of sodium chloride and continuous washing of peel with running water. The process of de-bittering of mosambi peel powder (MPP) using sodium chloride solution (0, 5, and 10%) was optimized. The optimization was based on the acceptable taste, maximum total polyphenol content, and maximum antioxidant properties of peel powder.

The optimized powder had total polyphenol content and antioxidant properties of $0.65 \pm 0.10\%$ and $57.05 \pm 0.08\%$, respectively, while taste was in acceptable limits and showed good, swelling power, water binding capacity, oil binding capacity, emulsion stability, and emulsion activity.

Practical Applications Mosambi peel powder is rich in dietary fiber and other bioactive compounds. However, its utilization is limited due to the presence of some bitter compounds. The present study deals with the optimization of de-bittering process of mosambi peel. The optimized powder had convincing functional properties and hence opens the doors for its commercial application in food industry. Mosambi peel powder being rich in dietary fiber can enhance the fiber content of some fiber deficient foods.

Mosambi peel



**Dibittering using
sodium chloride**



Modelling



Optimization of GA



**Di- bittered mosambi peel
powder**

Physico-chemical properties

- Antioxidant properties
- Reduce blood glucose level
- Antimicrobial properties
- High polyphenol content
- High dietary fiber



Functional Properties

- Solubility
- Water binding capacity
- Oil binding capacity

3.4-Optimization of Muffins recipe

A **muffin** is an individually portioned baked product, however the term can refer to one of two distinct items: a part-raised flatbread (like a crumpet) that is baked and then cooked on a griddle (typically unsweetened), or an (often sweetened) quickbread (like a cupcake) that is chemically leavened and then baked in a mold. While quickbread "American" muffins are often sweetened, there are savory varieties made with ingredients such as corn and cheese, and less sweet varieties like traditional *bran muffins*. The list and quantity of ingredients are mentioned in table 2(a) and 2(b). The process diagram of muffins is mentioned below and the variation of mosambi peel powder and flour was done:

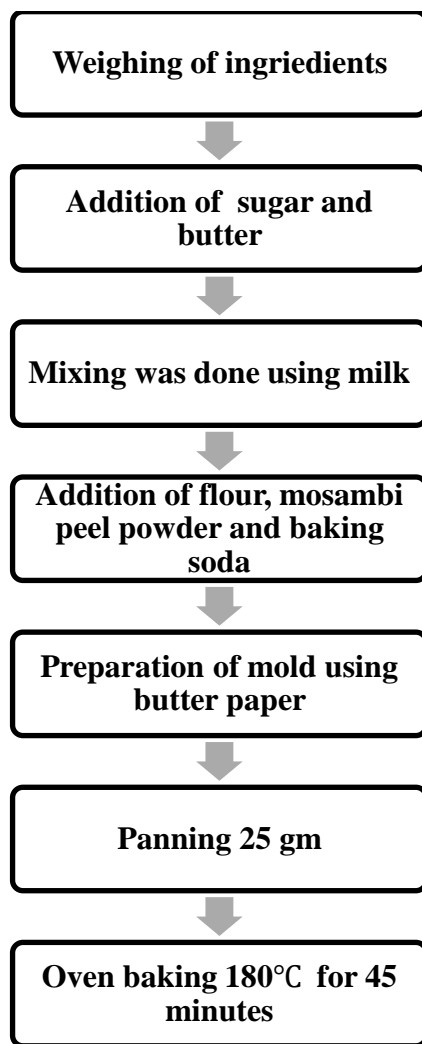


Figure 1: Flow sheet of muffin preparation

Table 2 (a): The list and quantity of ingredients for muffins.

S.no	Ingredients	Quantity
1	Wheat flour	Varied amount
2	Sugar	15 gm
3	Milk	100 ml
4	Baking powder	3 gm

5	Salt	3 gm
6	Butter	50 gm
7	Vanilla essence	2 drops
8	Peel powder	Varied amount

Table 2(b): The varied composition of flour and peel powder

Treatment	Peel powder (gm)	Flour (gm)
T₀	0	100
T₁	5	95
T₂	10	90
T₃	15	85
T₄	20	80
T₅	25	75
T₆	30	70

3.5- Analysis Performed

3.5.1- Proximate analysis

a) Moisture Content

Initially, an electronic balance was used to determine the weight of an empty Petri dish. In a flat bottomed dry tarred plate, 5g of each sample was weighed. The dish and its contents were put in a hot air oven with a thermostatically regulated temperature of $75 \pm 10^{\circ}\text{C}$ and cooked until no more weight loss was observed. Finally, the dish was taken out of the oven and placed in desiccators, where it was allowed to cool before being weighed again. The moisture content of flour, peel powder and muffin samples was calculated using the method below (Rohmah et al., 2022).

$$\text{Moisture content(\%)} = \frac{\text{Loss in weight of sample(g)}}{\text{Initial weight of sample(g)}} \times 100$$

b) Ash Content

The empty weight of the crucible was taken. 5g of every sample were weighed in the crucible. It was then ignited on the flame. The crucible and its content were placed in a muffle furnace at 550°C for 5 hours (Kumar et al., 2022). The crucibles were removed from the furnace and placed in the desiccators to cool the samples. The weight was taken of every sample. The following formula was used for the estimation of the ash content of flour, peel powder and muffin samples (Marshall, 2011).

$$\text{Ash content(\%)} = \frac{\text{Weight of ash(g)}}{\text{Initial weight of sample(g)}} \times 100$$

c) Sensory Evaluation

The observation of sensory attributes was done for muffins. Sensory attributes including color, flavor, texture, taste, and after-test of Muffins were evaluated by Hedonic Rating Test. Hedonic Rating tests were being used for the evaluation of sensory characteristics. This test is used to measure the acceptability of consumers for the product (Muenprasitivej, N.*et al.*, 2022; Schouteten et al., 2018). The detailed methodology is presented below.

The samples were presented to a panel of five professional judges from various age groups and with varying eating habits. The expert panellists were asked to score the product's acceptability using a sense of organs on a scale of 9 points ranging from strongly like to extremely dislike. (Ray, S. 2021). A test Performa was prepared and supplied to them at the time of evaluation.

4. Result and Discussion

4.1-Muffins Preparation

The muffins with different concentration of flour and peel powder was prepared with the flow-sheet mentioned above. The colour and taste varied with the composition of peel powder. As the peel powder increased the colour became darker and after taste was more.



Figure 4.1- Picture of muffins prepared with different concentration of peel powder.

4.2- Analysis performed

4.2.1-Moisture content

The moisture content of peel powder was 0.625% and for flour it was 0.511%. The moisture content of muffins ranged from 16.20 to 17.20%. The moisture content of muffins increased with increasing the peel powder as shown in **fig. 4.2**.

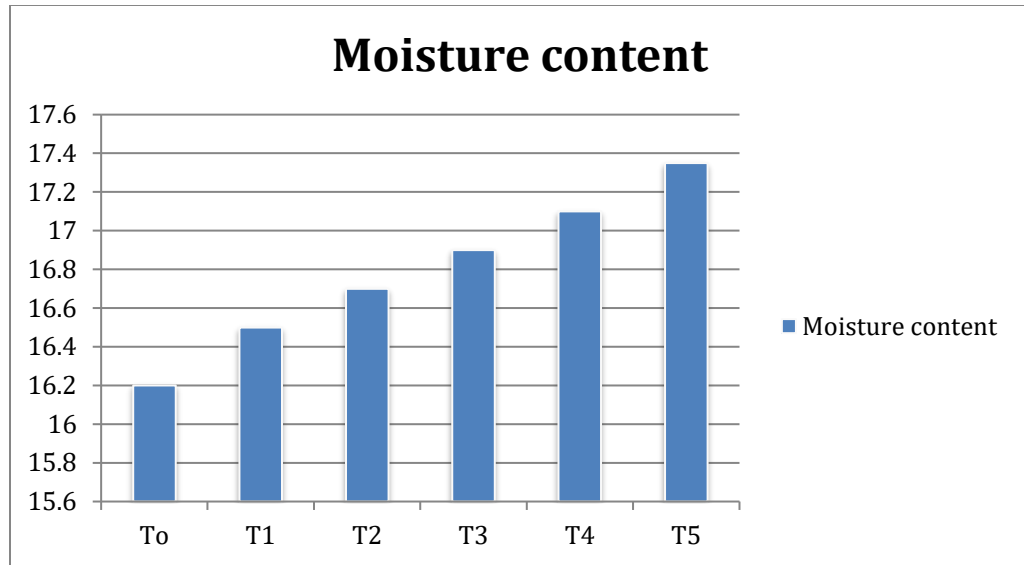


Figure 4.2: The graphical representation of variation in moisture content of muffins.

(a) Ash content

The ash content of peel powder was 0.03% and for flour it was 0.935%. The moisture content of muffins ranged from 1.59 to 1.71%. The moisture content of muffins increased with increasing the peel powder as shown in **fig. 4.3**

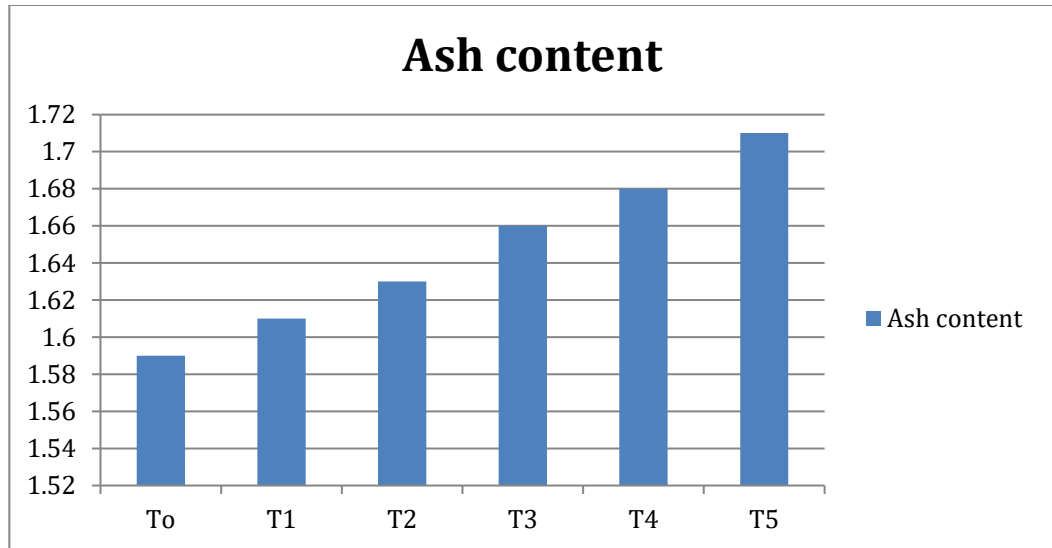


Figure 4.3: The graphical representation of variation in moisture content of muffins.

(b) Sensory evaluation

Sensory attributes of Muffins were evaluated at fresh condition using control and muffins of different concentration of peel powder. Nine point Hedonic rating Proportion method was used for the evaluation of different samples of Muffins. Different attribute selected were colour, taste, flavour, texture, appearance, after-taste and overall acceptability shown in **fig. 4.4**.

The colour was darker with increasing the peel powder concentrate. The texture and taste was also affected with increasing the peel powder concentrate. The after-taste of peel was more at the muffins which have higher concentration of peel powder. The overall acceptability of Muffins decreased with increasing the peel powder concentration.

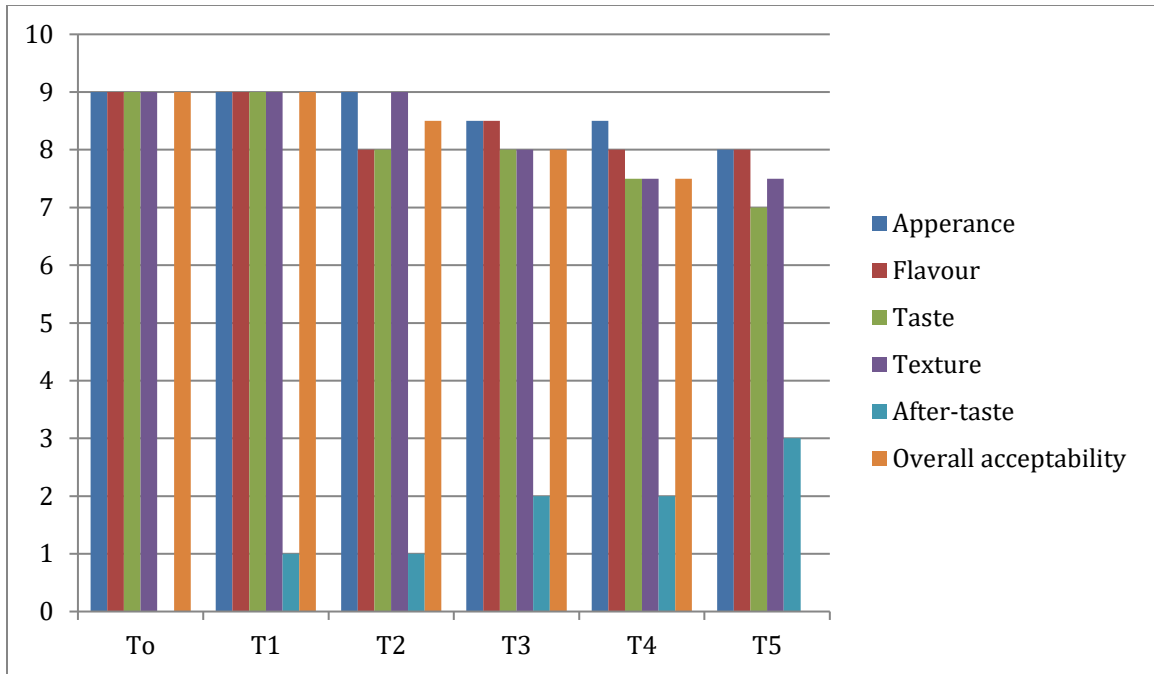


Figure 4.4: The graphical representation of sensory evaluation of muffins.

Conclusion

Recent research concerning functional properties of citrus by-products especially peel has added to our knowledge. Due to the low cost and easy availability of fruit residues which otherwise would be discarded as waste in the environment should be regarded as potential nutraceutical resources, capable of offering significant low-cost, nutritional dietary supplements. During this study it was observed that by addition of Mosambi peel powder in muffins the moisture and ash content of muffins has increased. The colour, taste, texture, after-taste and overall acceptability was also affected by increasing the concentration of muffins. Rich in bioactive compounds, these unwanted cast-offs of manufacturing could be recycled as value added food supplements, that provide advantageous dietary fibre and polyphenols. The extracts from fruit peel hold promise in food industry as sources of bioactive compounds. In addition, an established use of the citrus peel would also help alleviate pollution problems caused because of the poor disposal of such residues. More research is needed to establish bioavailability and real benefits of these peel extracts obtained from citrus peel

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